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Gromotka et al.

(10) **Patent No.: US 11,655,966 B2**
(45) **Date of Patent: May 23, 2023**

(54) **APPARATUS, METHOD, AND SYSTEM FOR REDUCING MOISTURE IN LED LIGHTING FIXTURES**

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(73) Assignee: **Musco Corporation**, Oskaloosa, IA (US)

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(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation-in-part of application No. 16/741,049, filed on Jan. 13, 2020, now Pat. No. 11,192,063.

(Continued)

(51) **Int. Cl.**

F21V 15/00 (2015.01)
F21V 29/76 (2015.01)

(Continued)

(52) **U.S. Cl.**

CPC ***F21V 15/00*** (2013.01); ***F21V 3/04*** (2013.01); ***F21V 29/763*** (2015.01); *F21Y 2115/10* (2016.08)

(58) **Field of Classification Search**

CPC F21V 15/00; F21V 3/04; F21V 29/763; F21V 31/03; F21Y 2115/10; F21W 2131/10

See application file for complete search history.

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Assistant Examiner — Glenn Zimmerman
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(57) **ABSTRACT**

Sealed LED lighting fixtures operated under certain conditions (e.g., outdoors, in cold ambient environments, at high operating current, and/or in non-hermetic environments) will oftentimes exhibit condensation on an inner surface of the emitting face of the fixture. When occurring, said condensation impairs the ability to produce useful light—namely, light harnessed and directed in a manner so to provide lighting for a task (or otherwise desired)—by diffusing light emitted from the lighting fixture. Envisioned are apparatus, methods, and systems to reduce moisture in sealed LED lighting fixtures so to reduce or eliminate condensation, and in a manner that addresses both fixtures already in the field and those being assembled in a factory setting. In one form, a carrier embedded with desiccant is positionally mounted inside the fixture in a desired position

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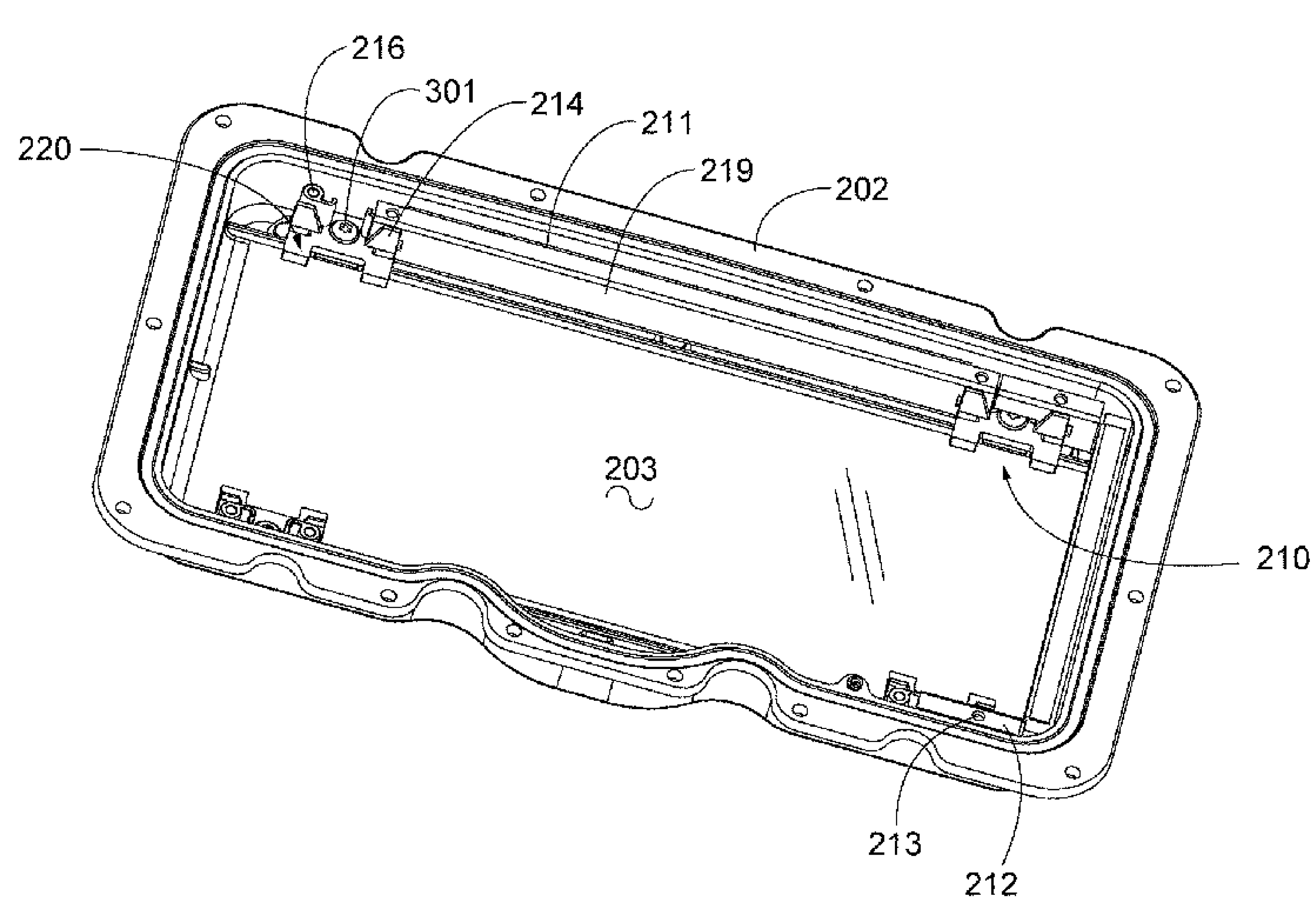

which has no or minimal impact on light output from the fixture.

19 Claims, 40 Drawing Sheets

Related U.S. Application Data

(60) Provisional application No. 62/799,281, filed on Jan. 31, 2019, provisional application No. 62/791,941, filed on Jan. 14, 2019.

(51) **Int. Cl.**
F21V 3/04 (2018.01)
F21Y 115/10 (2016.01)

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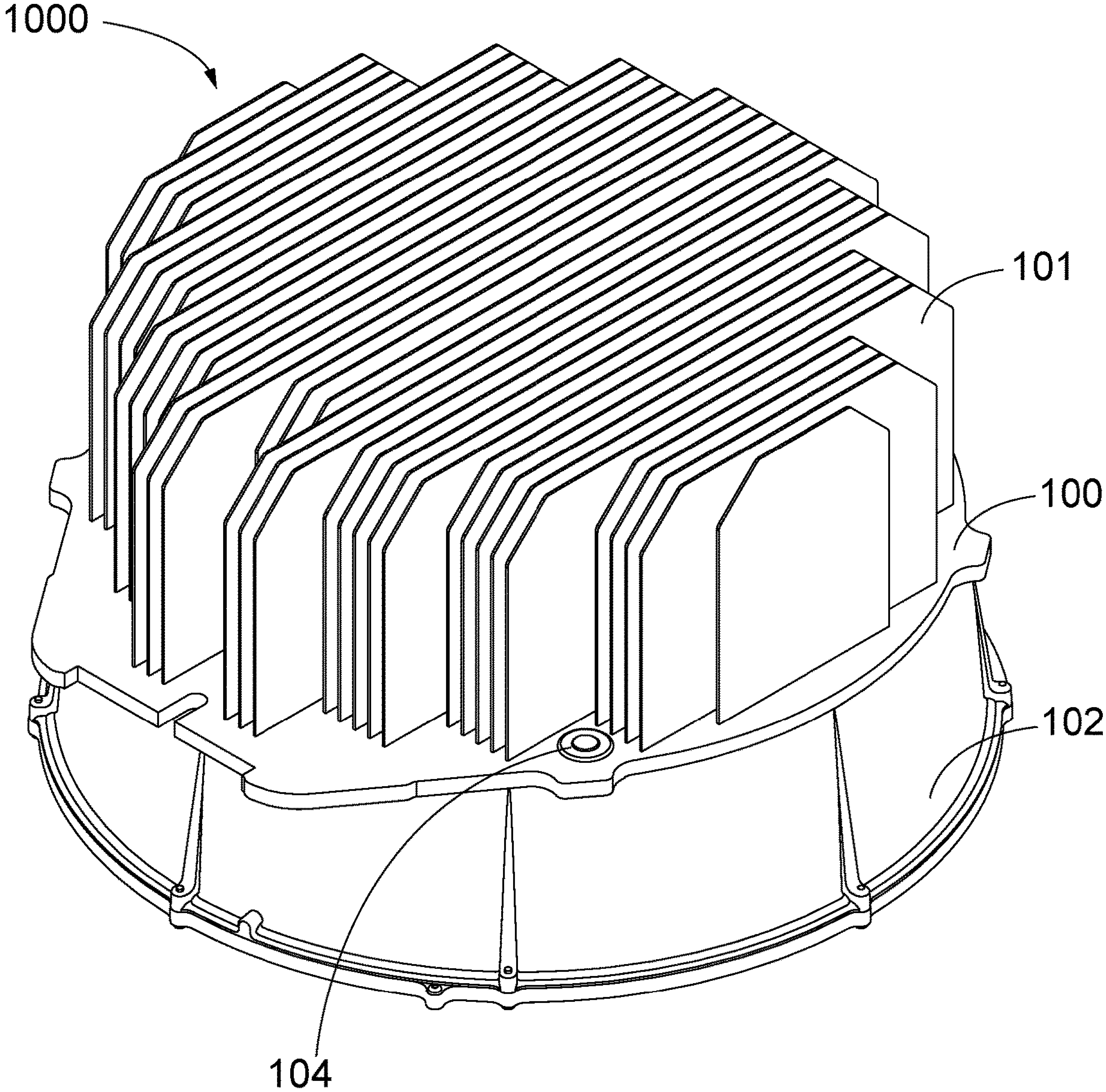

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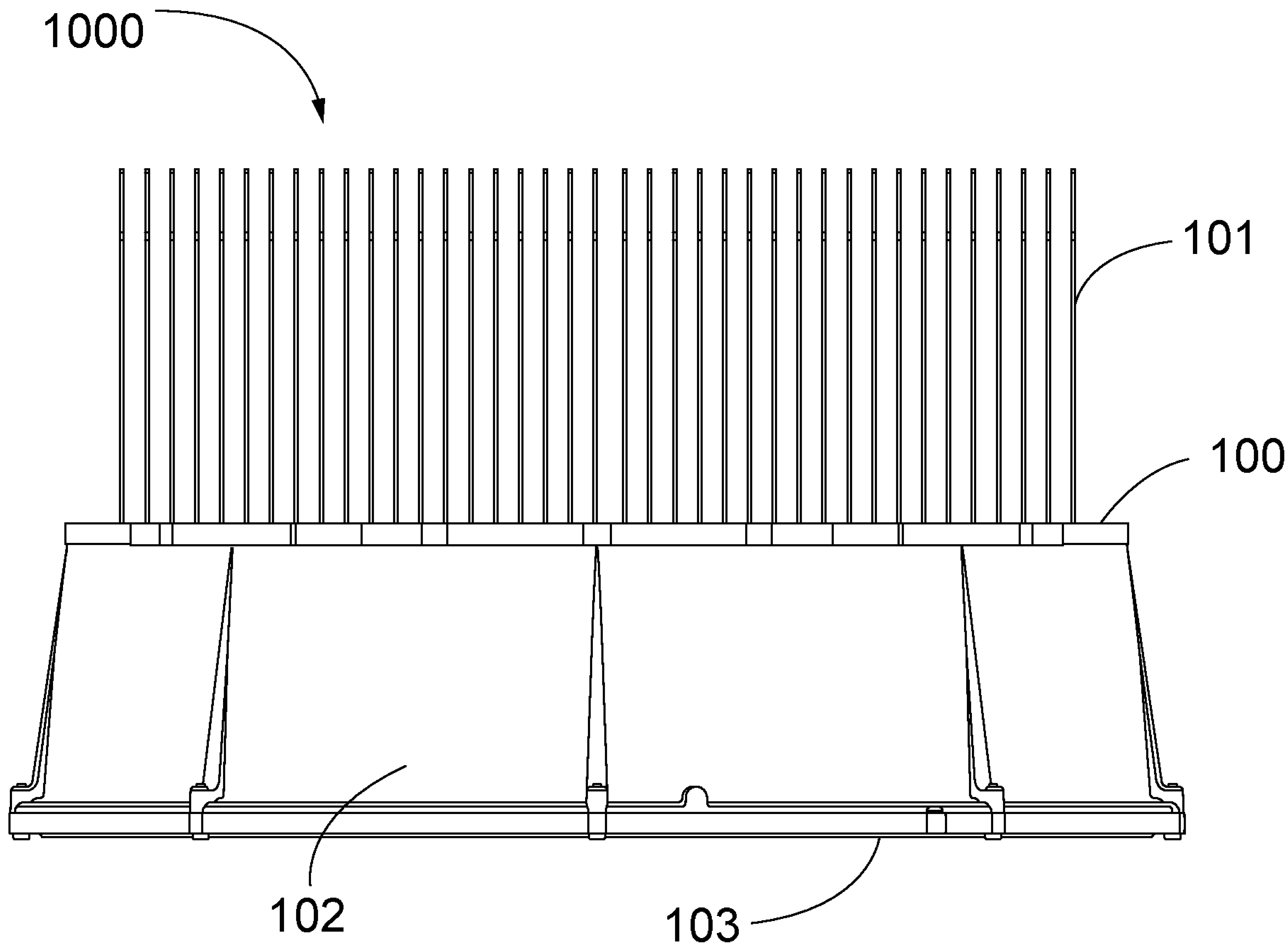

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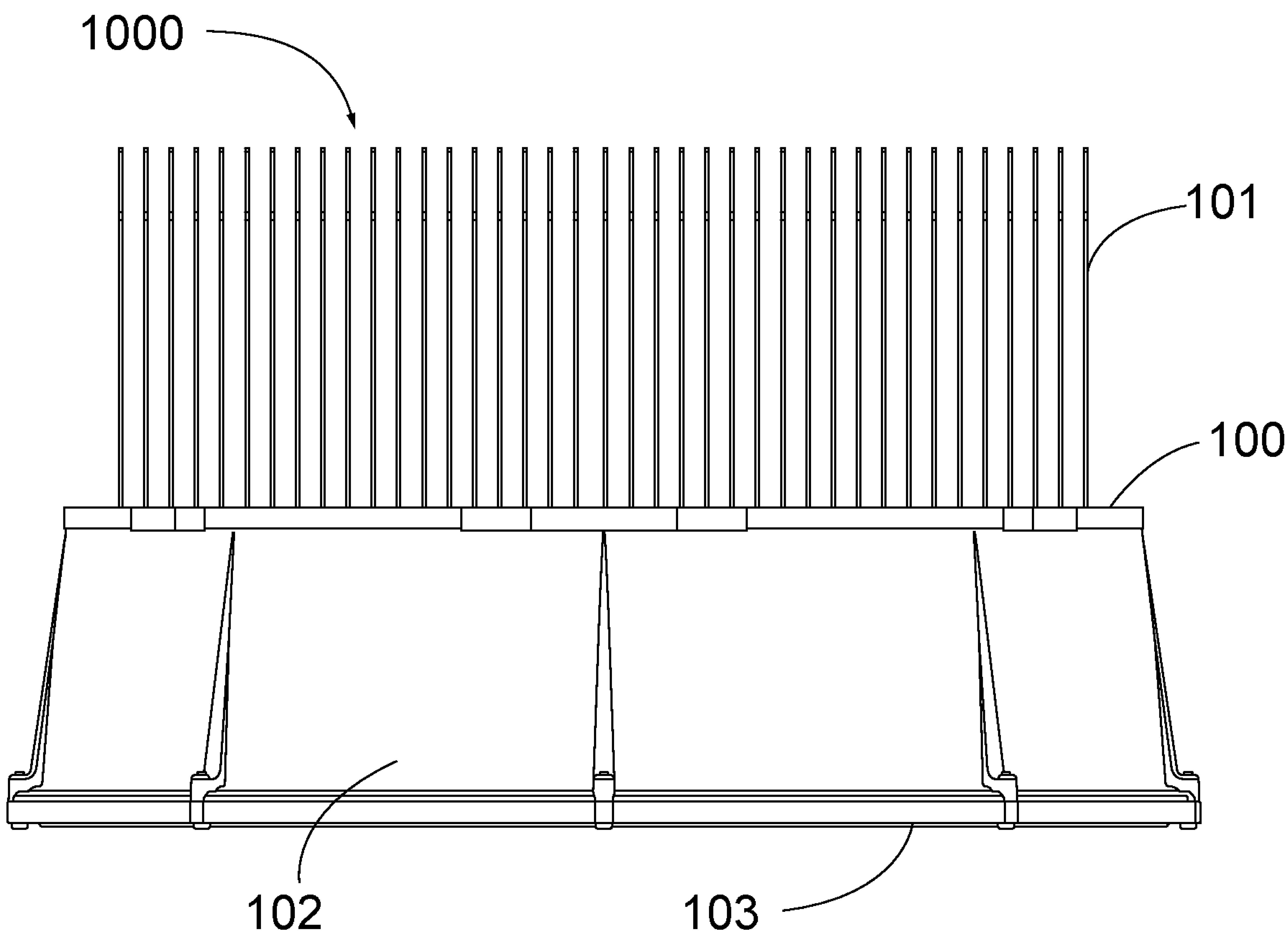

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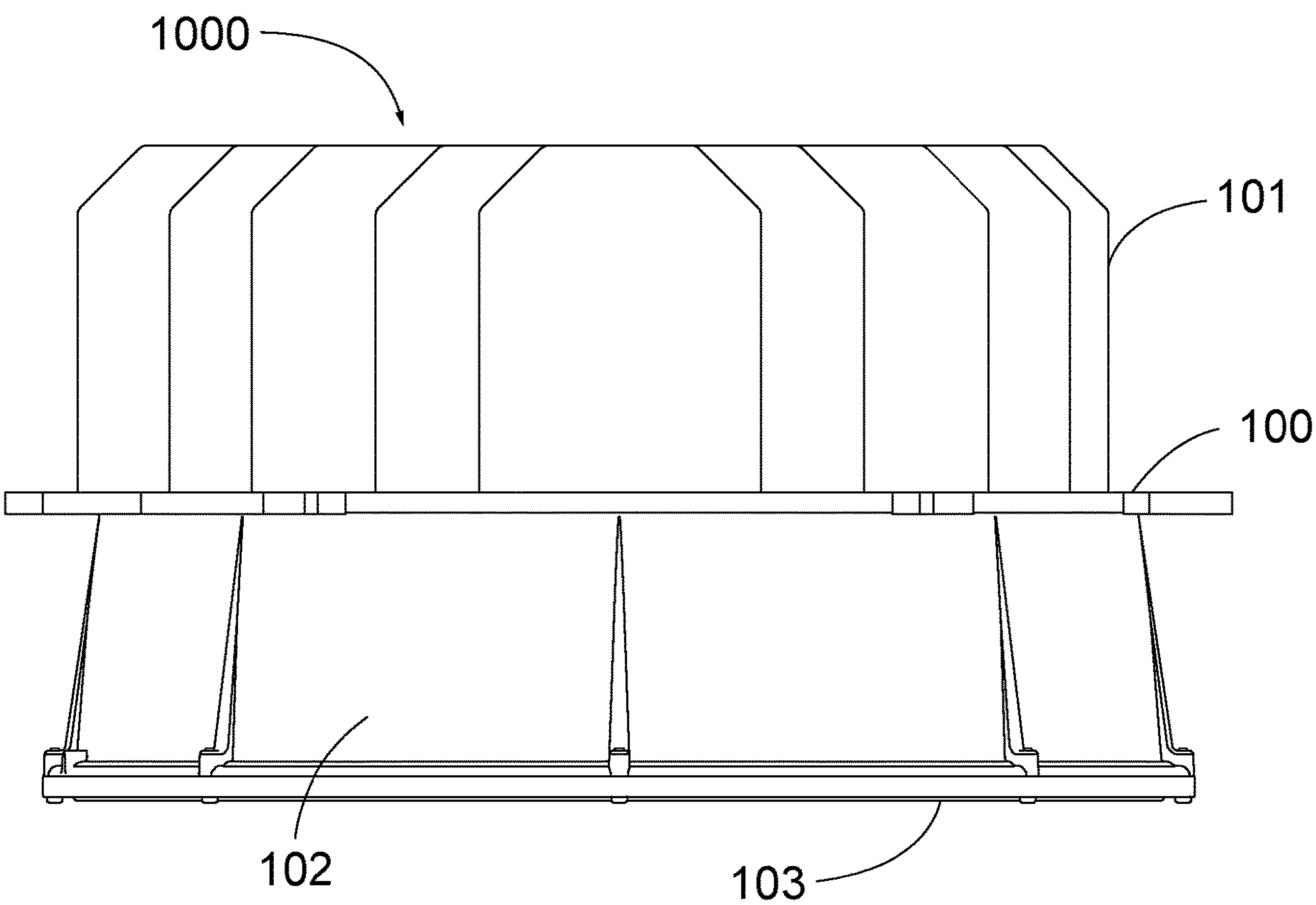

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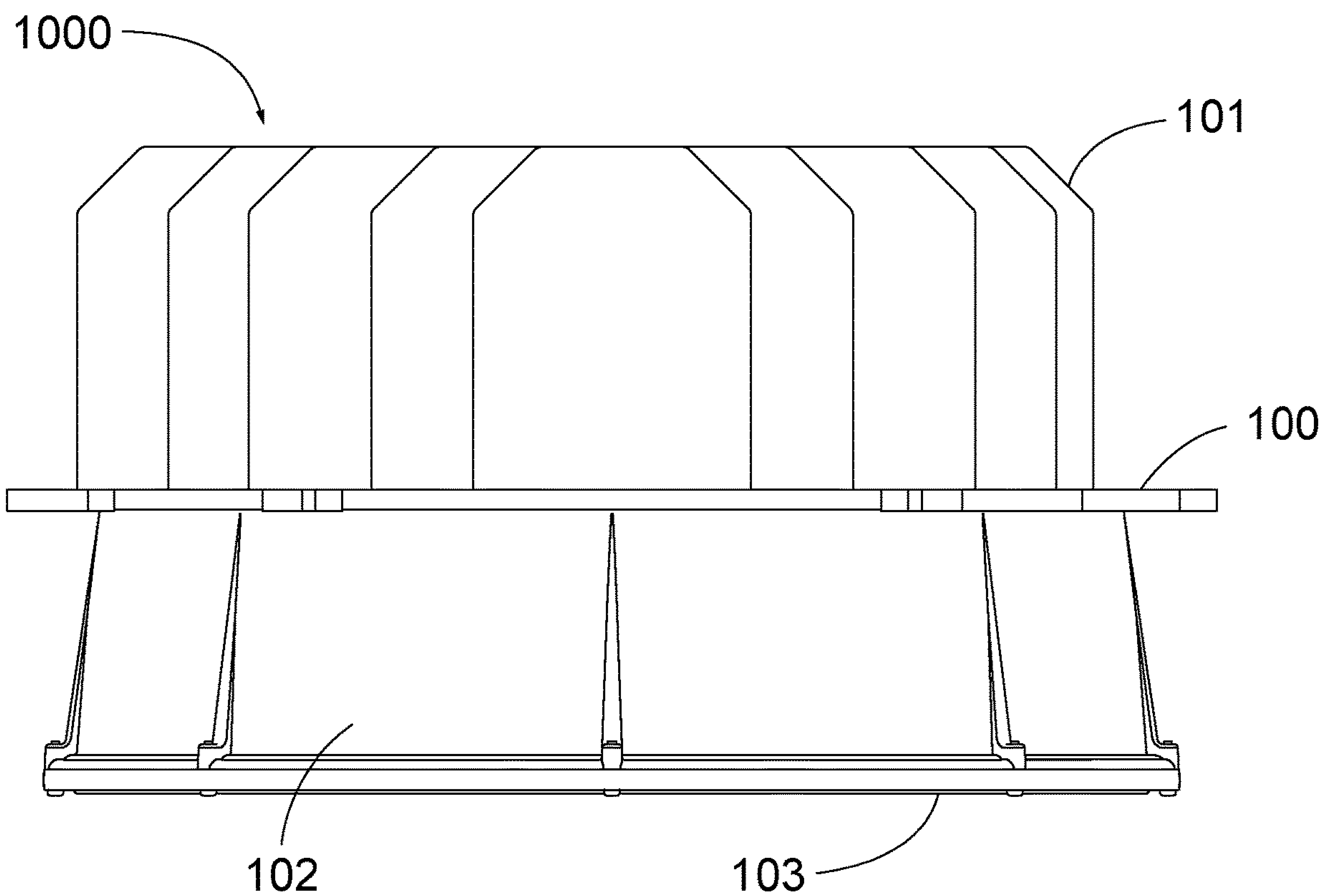

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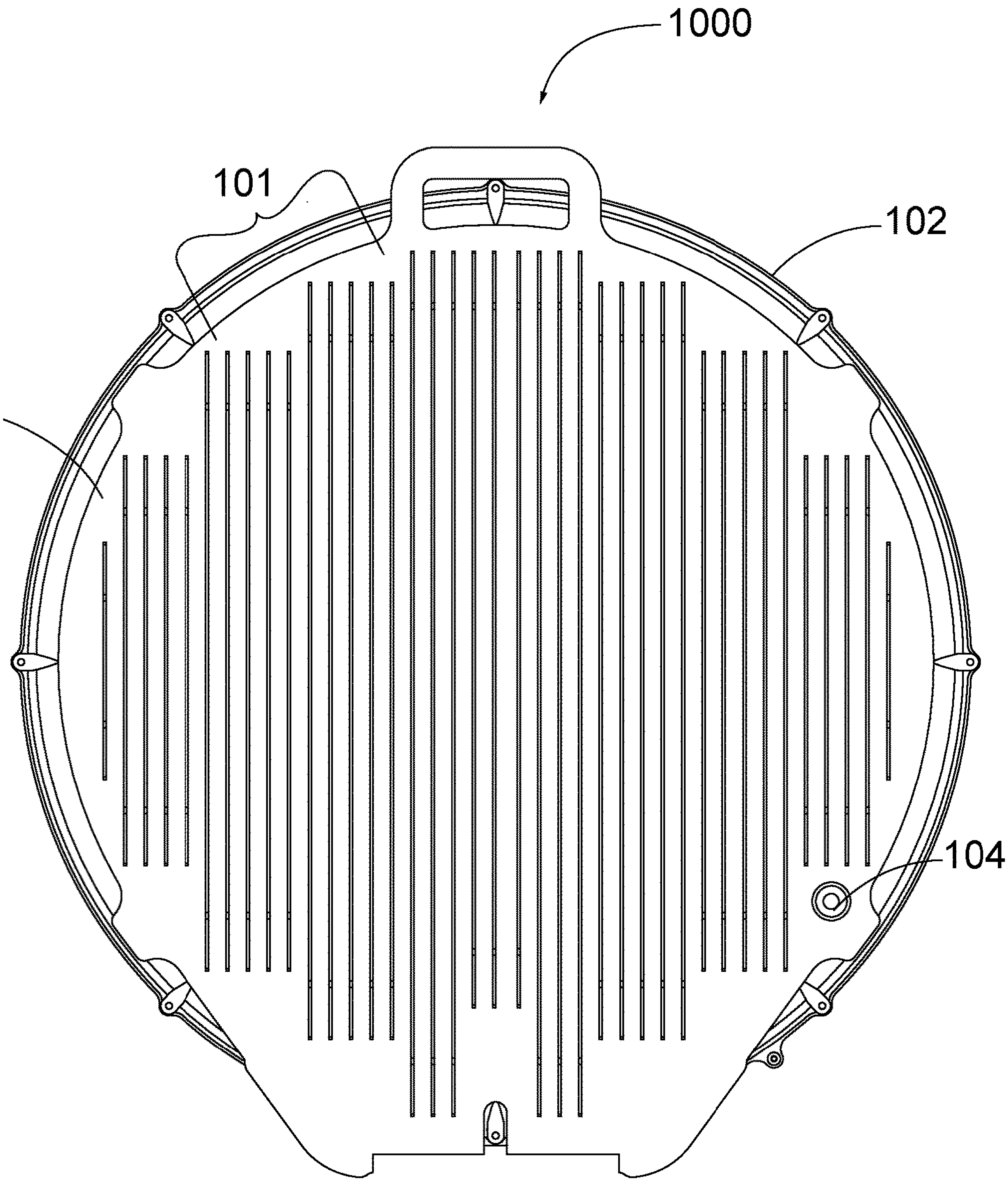

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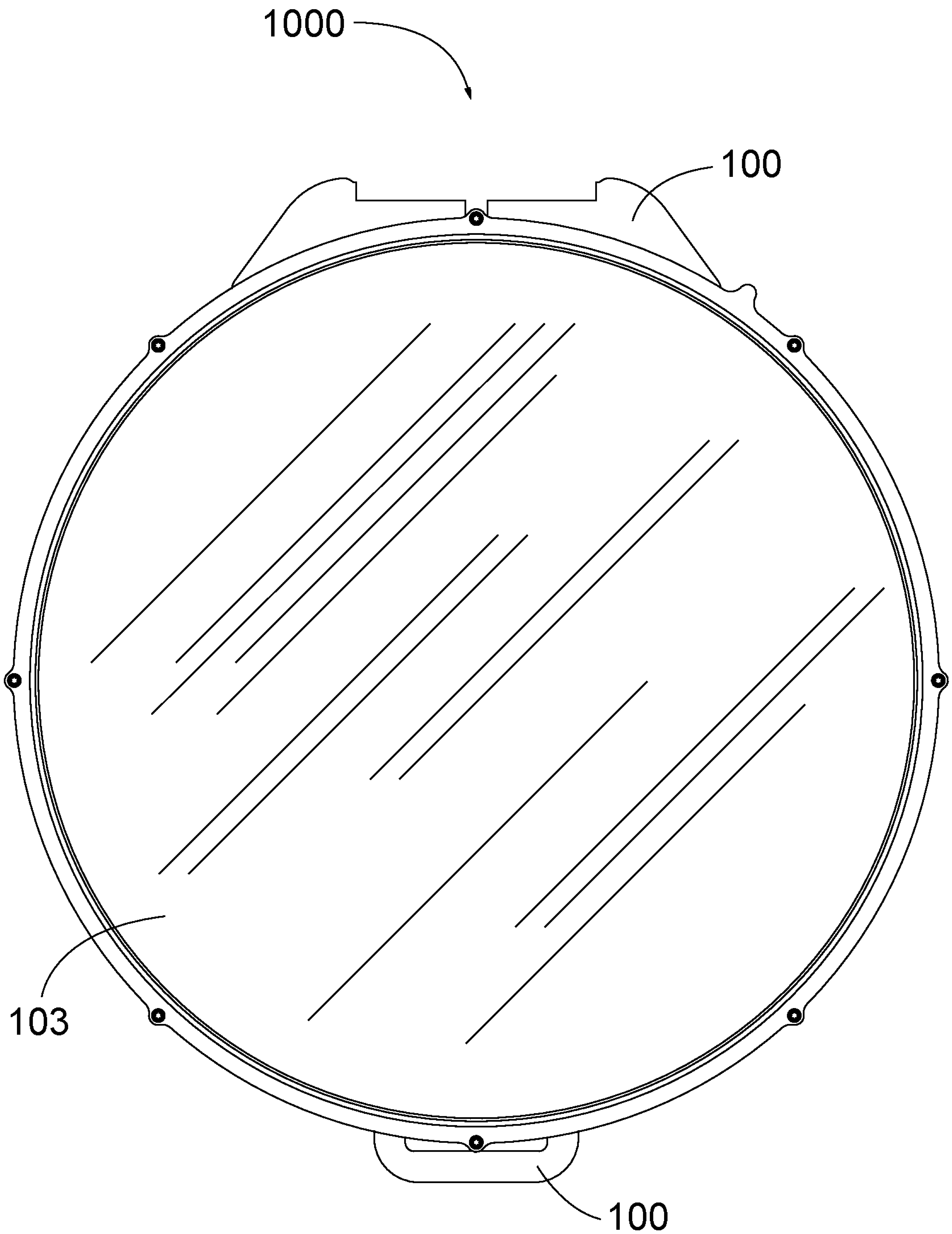

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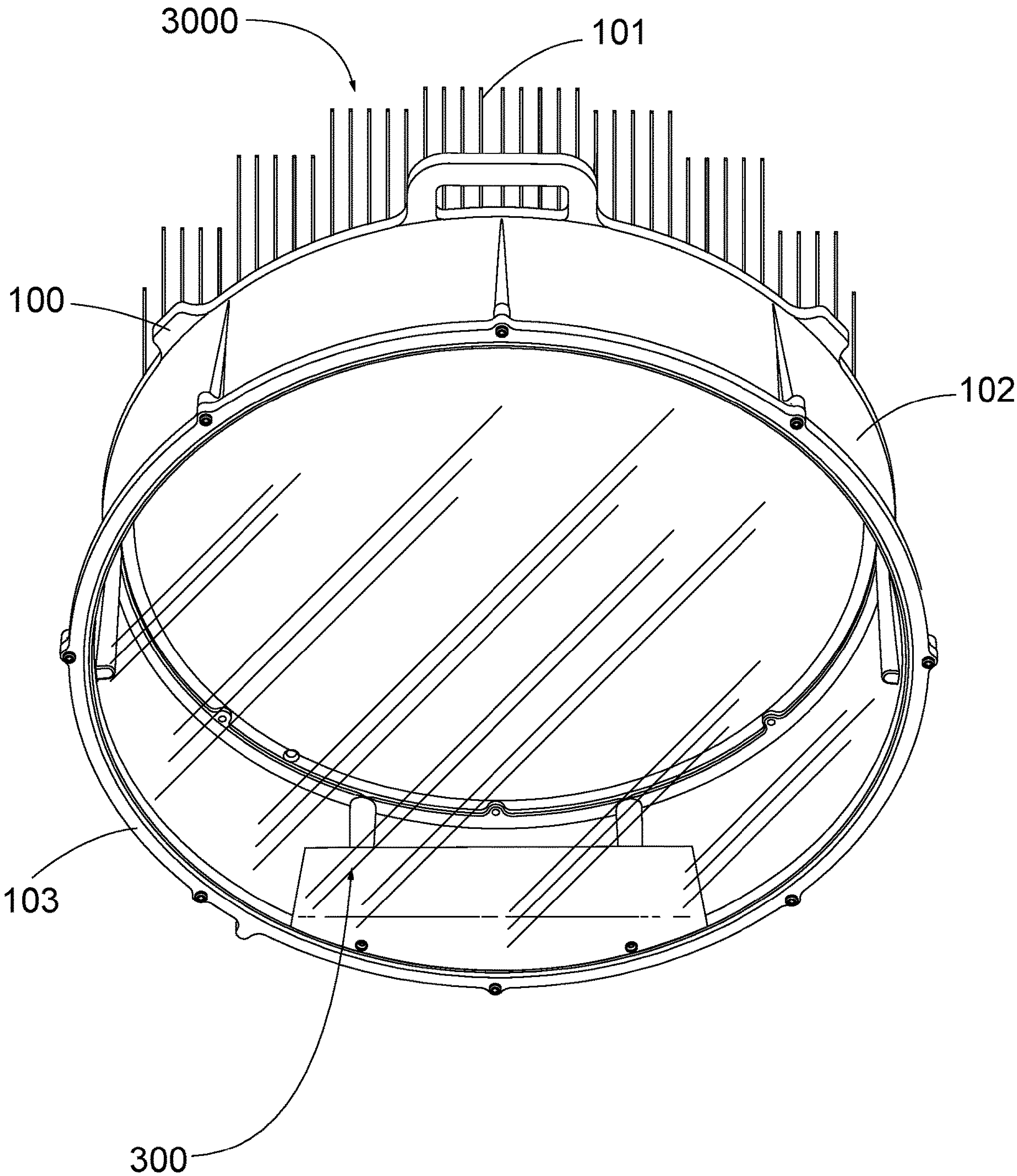

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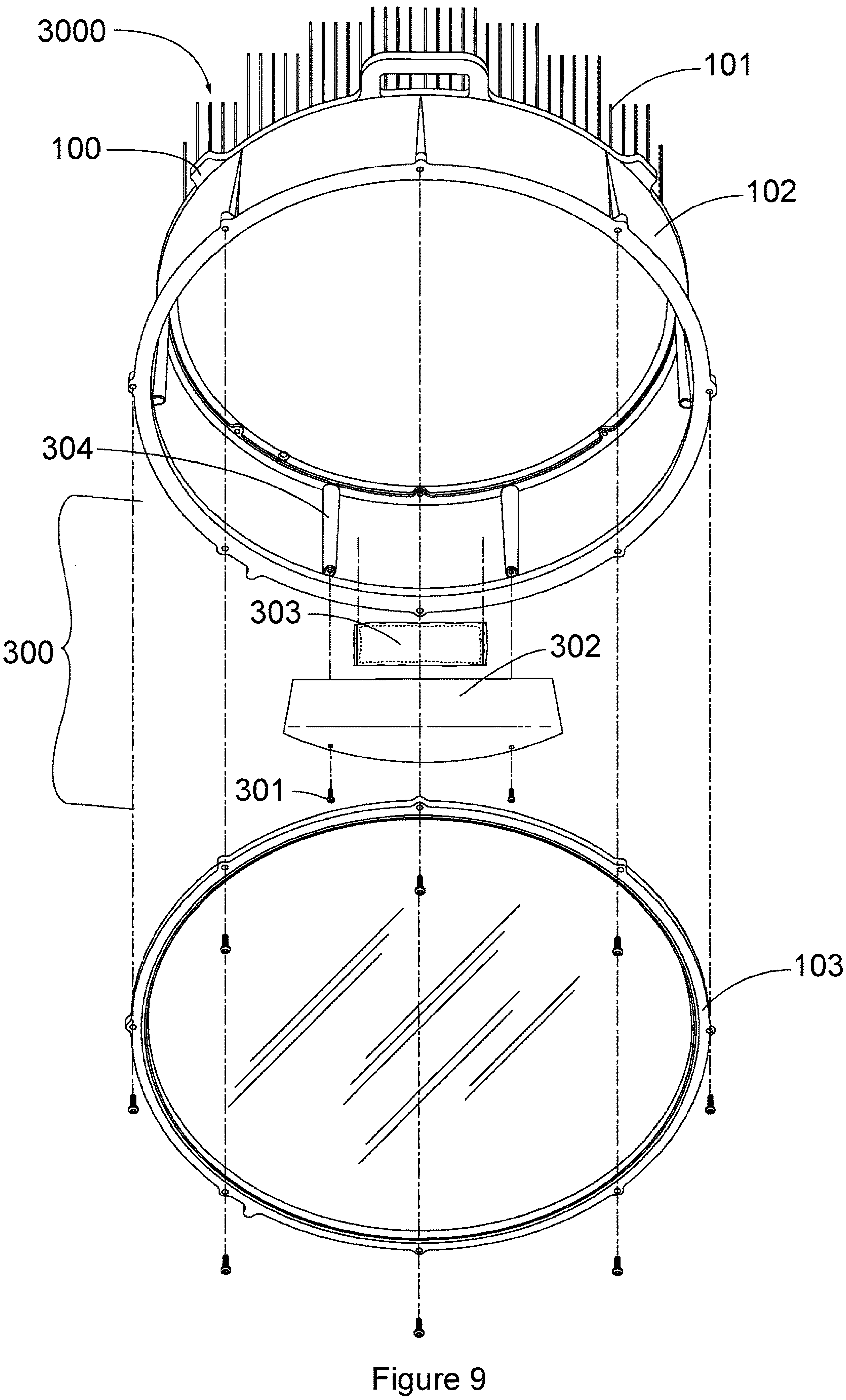

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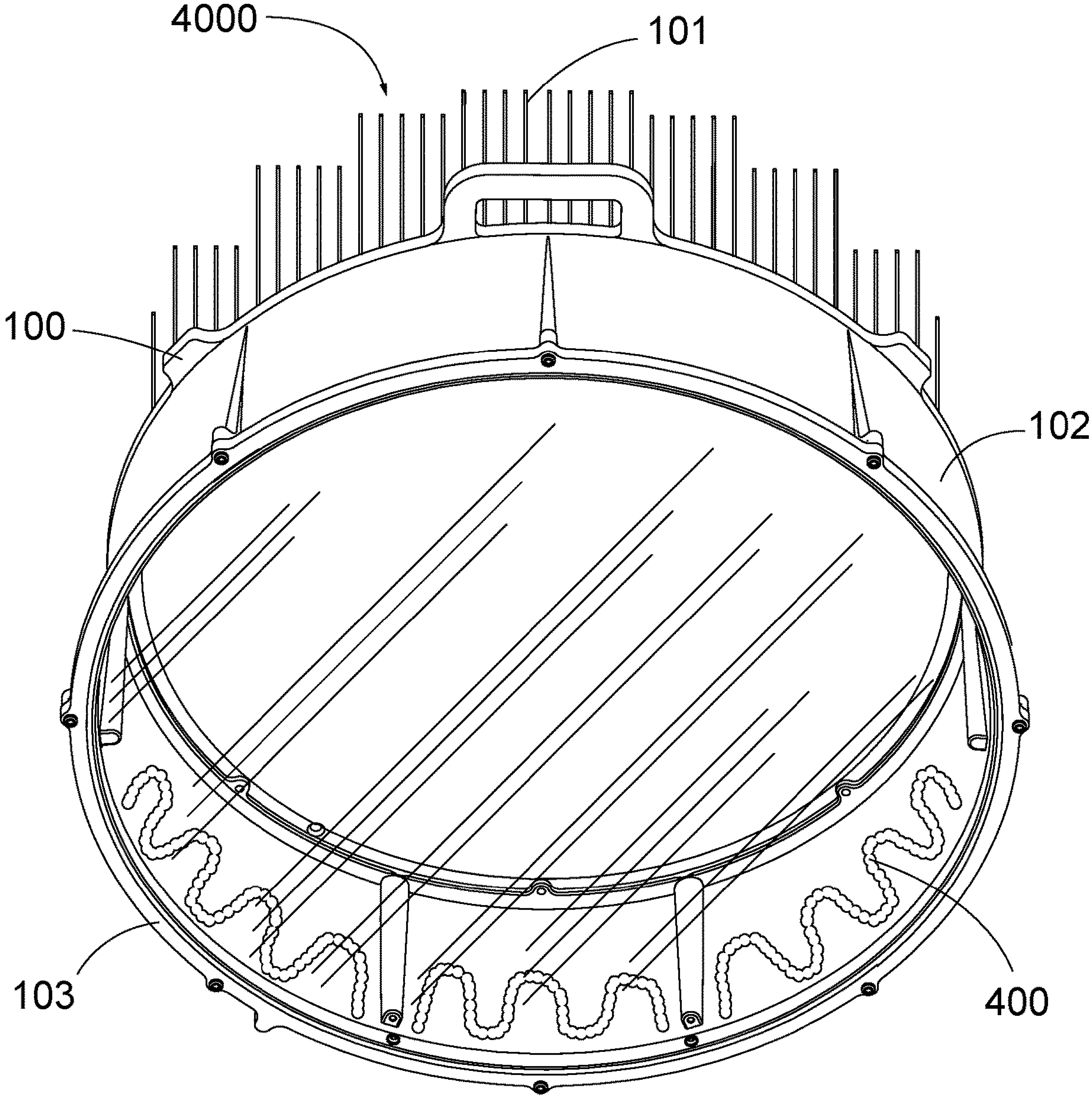

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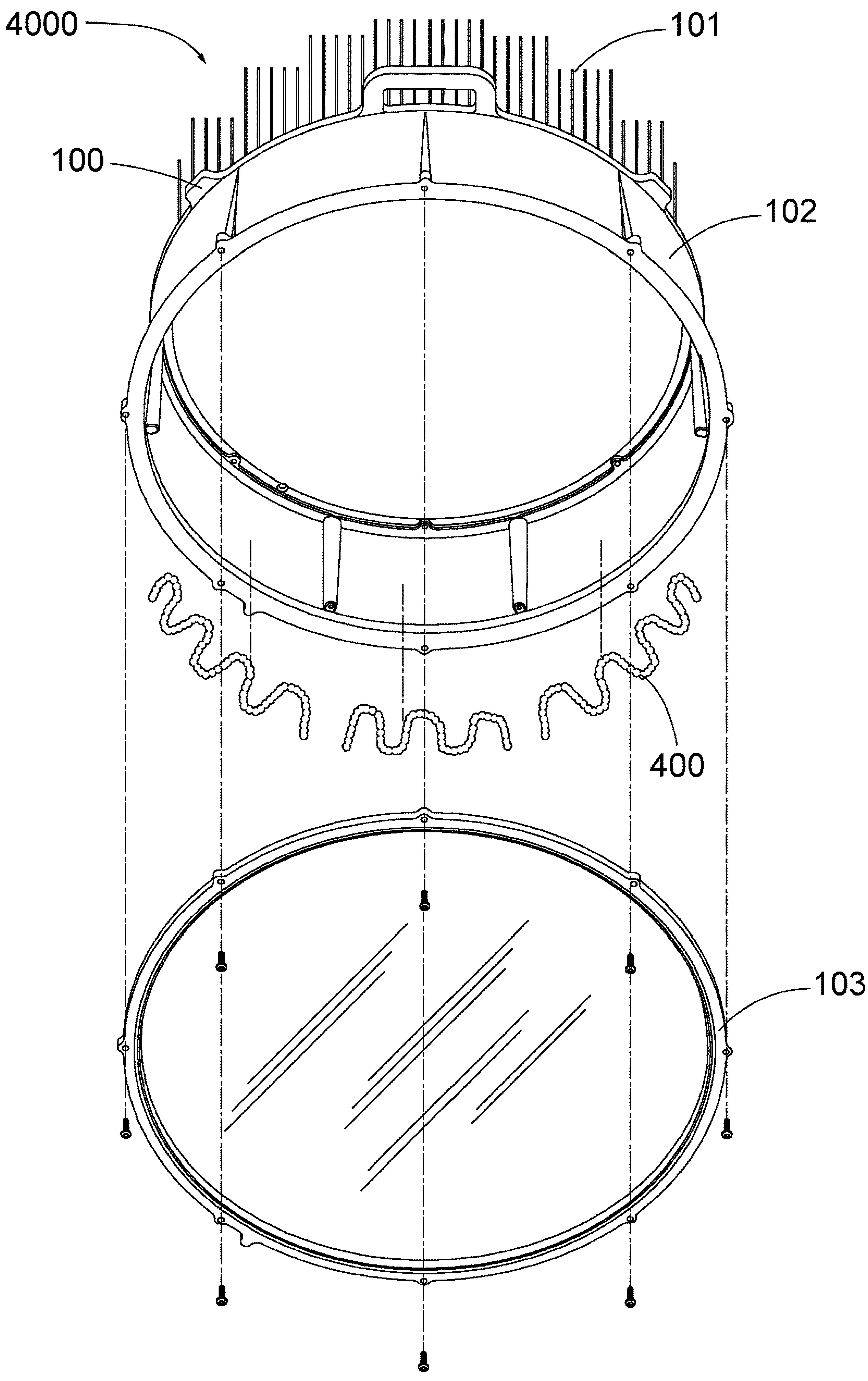

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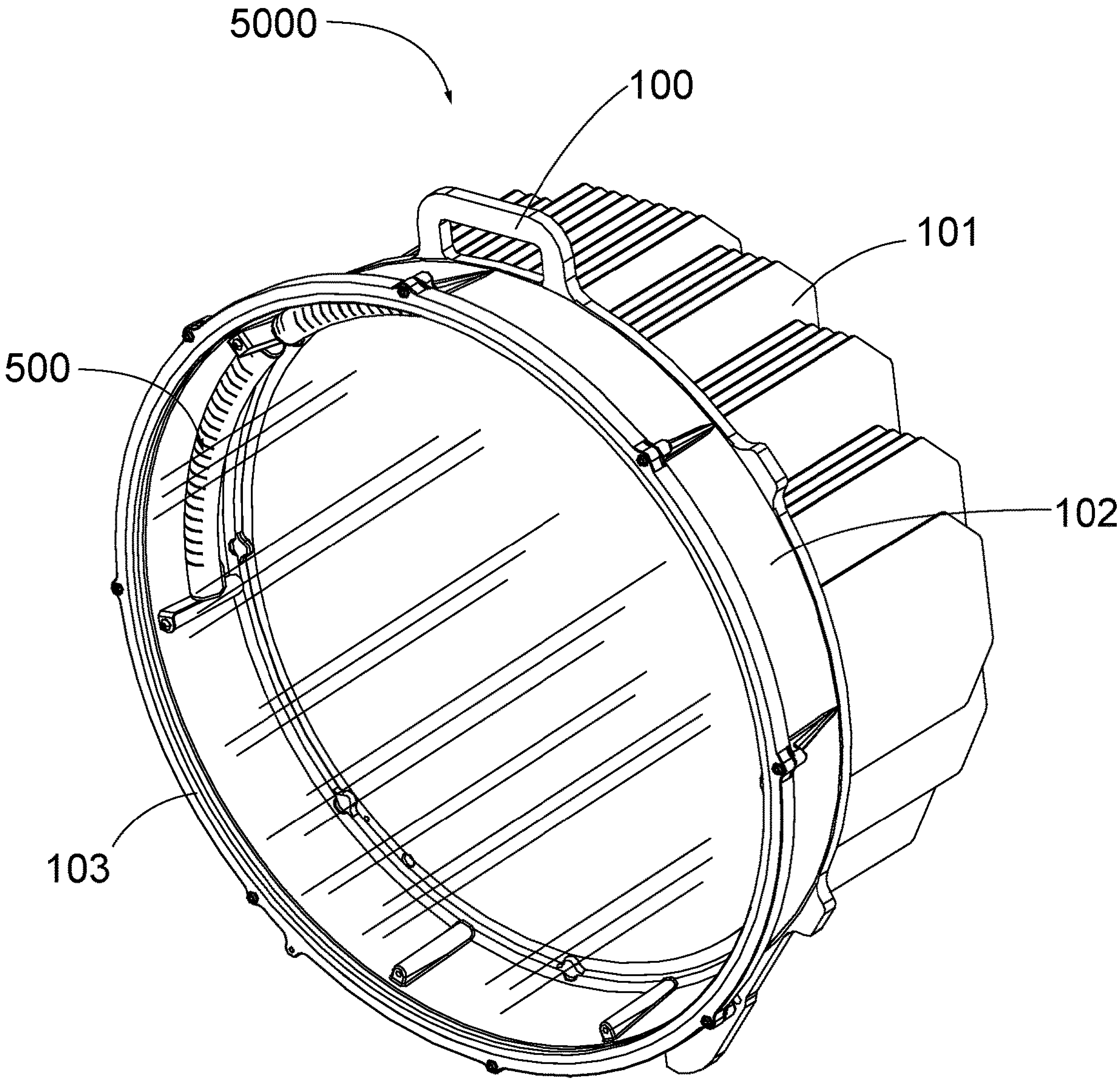

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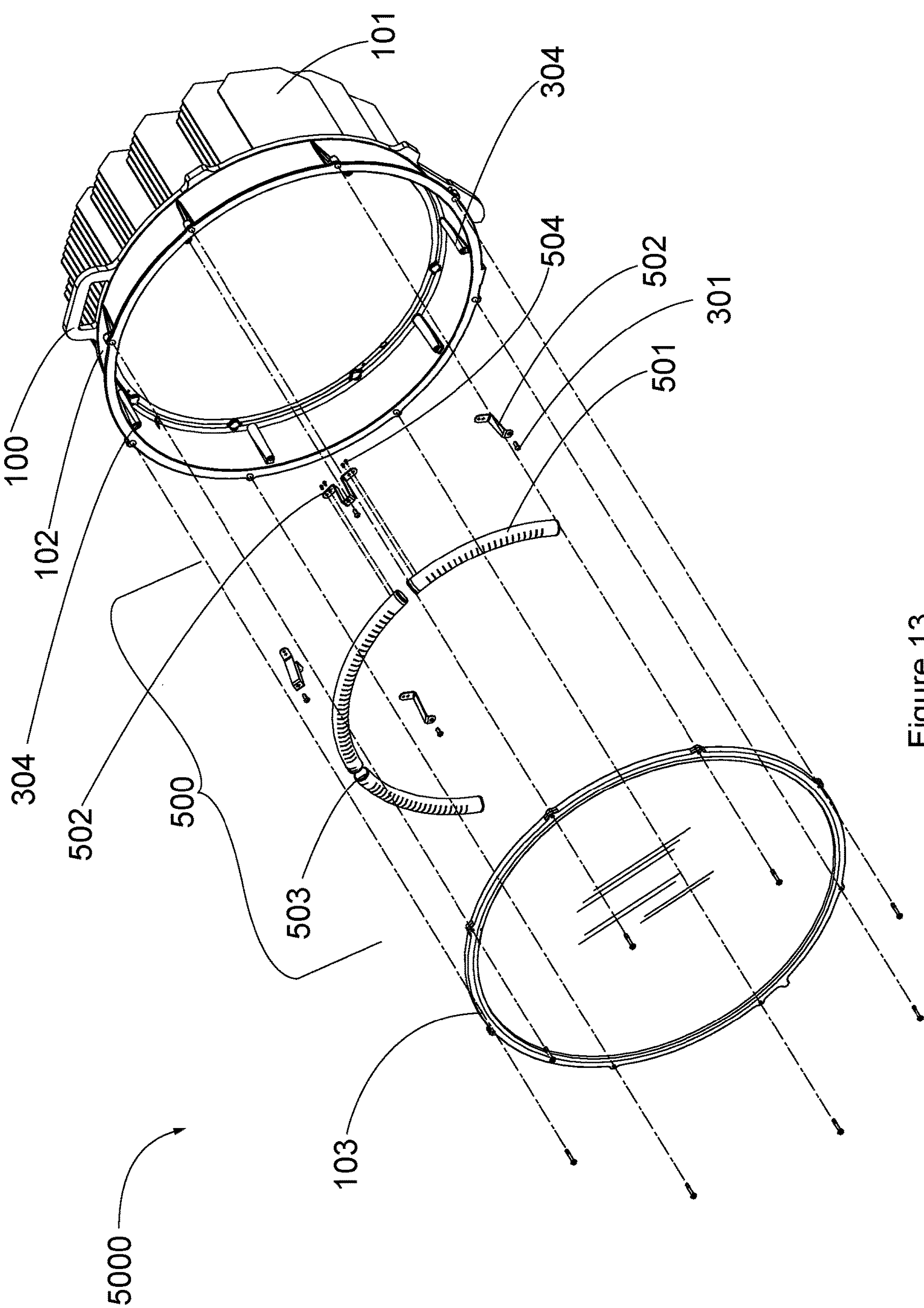

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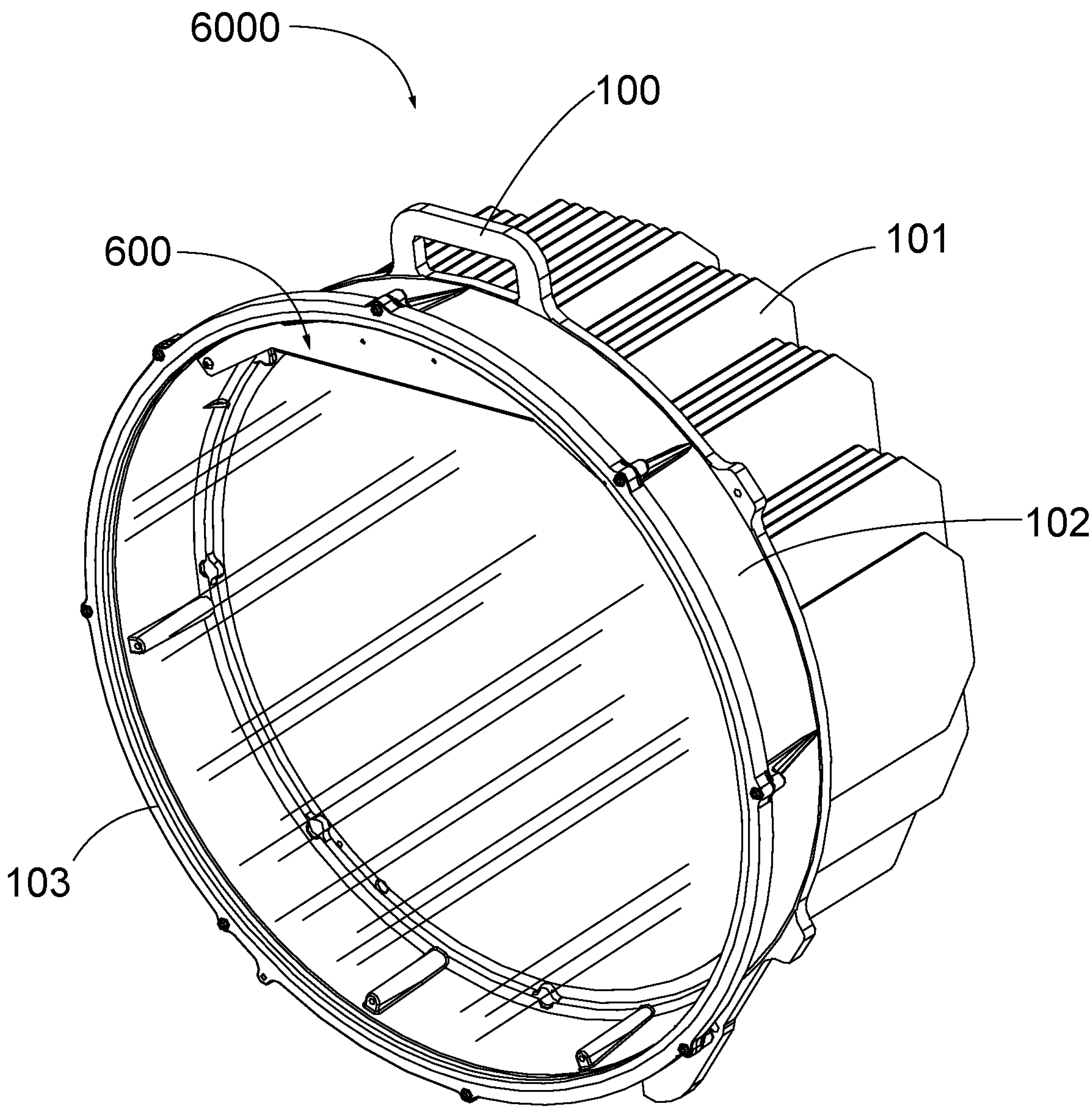

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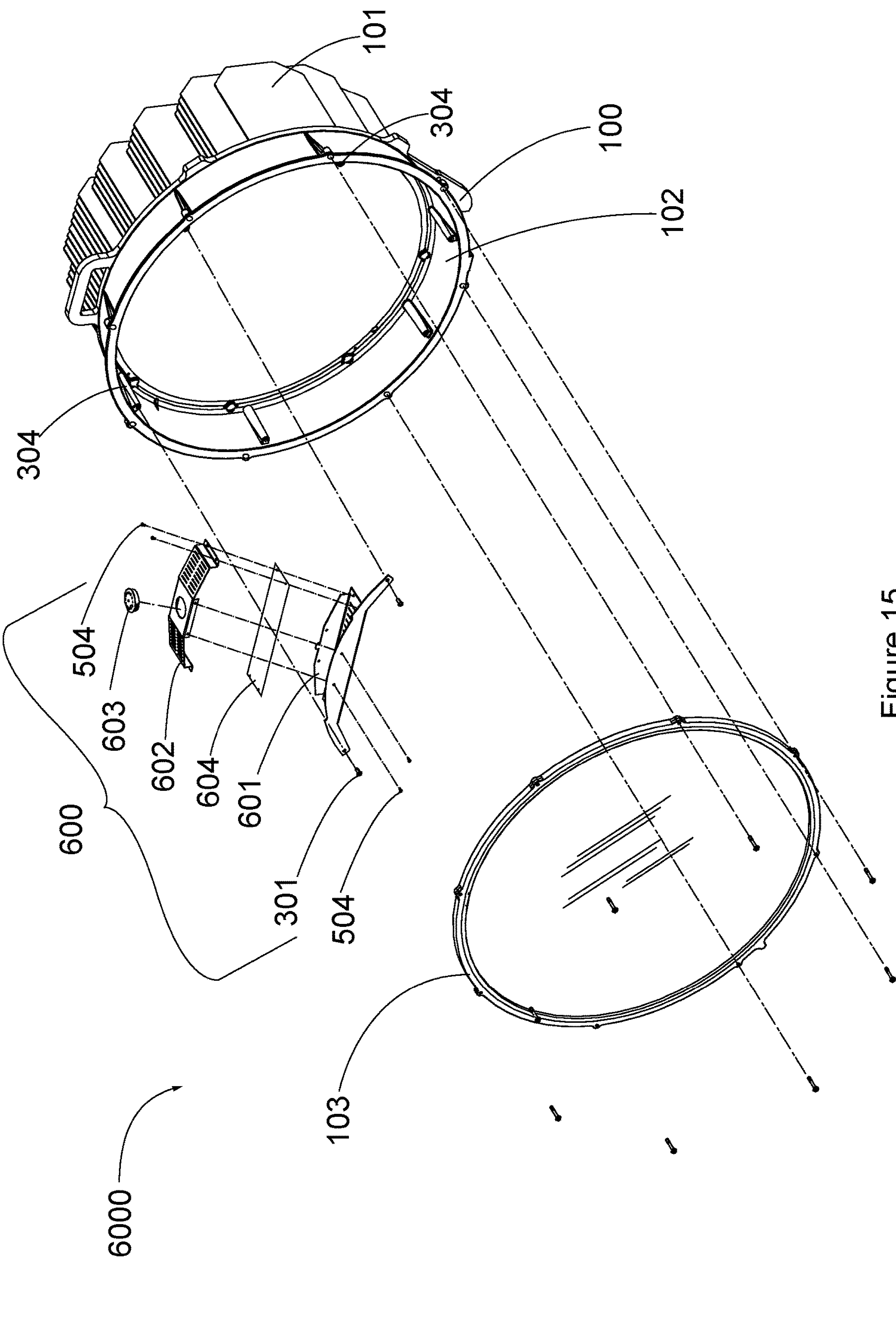

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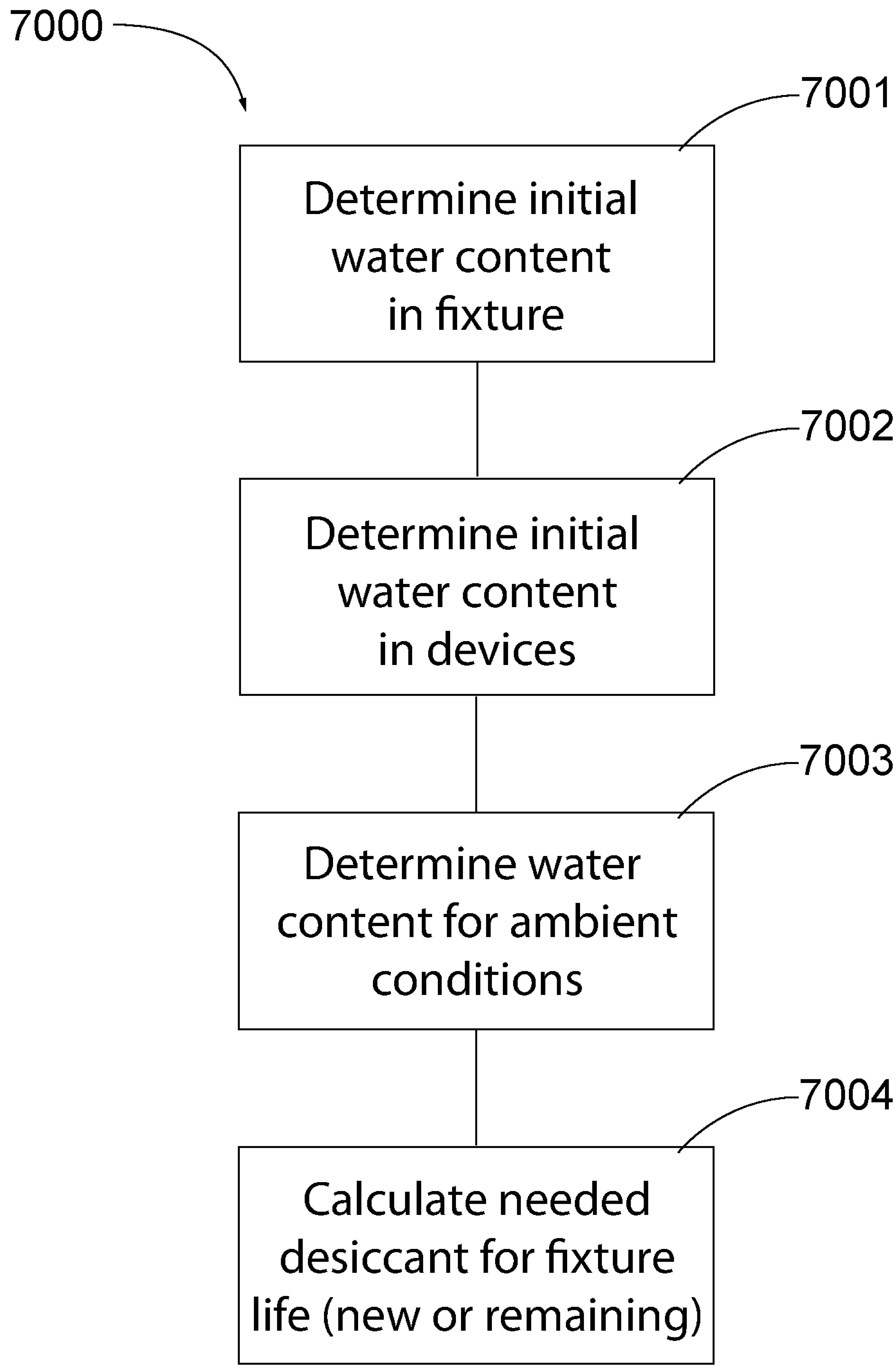
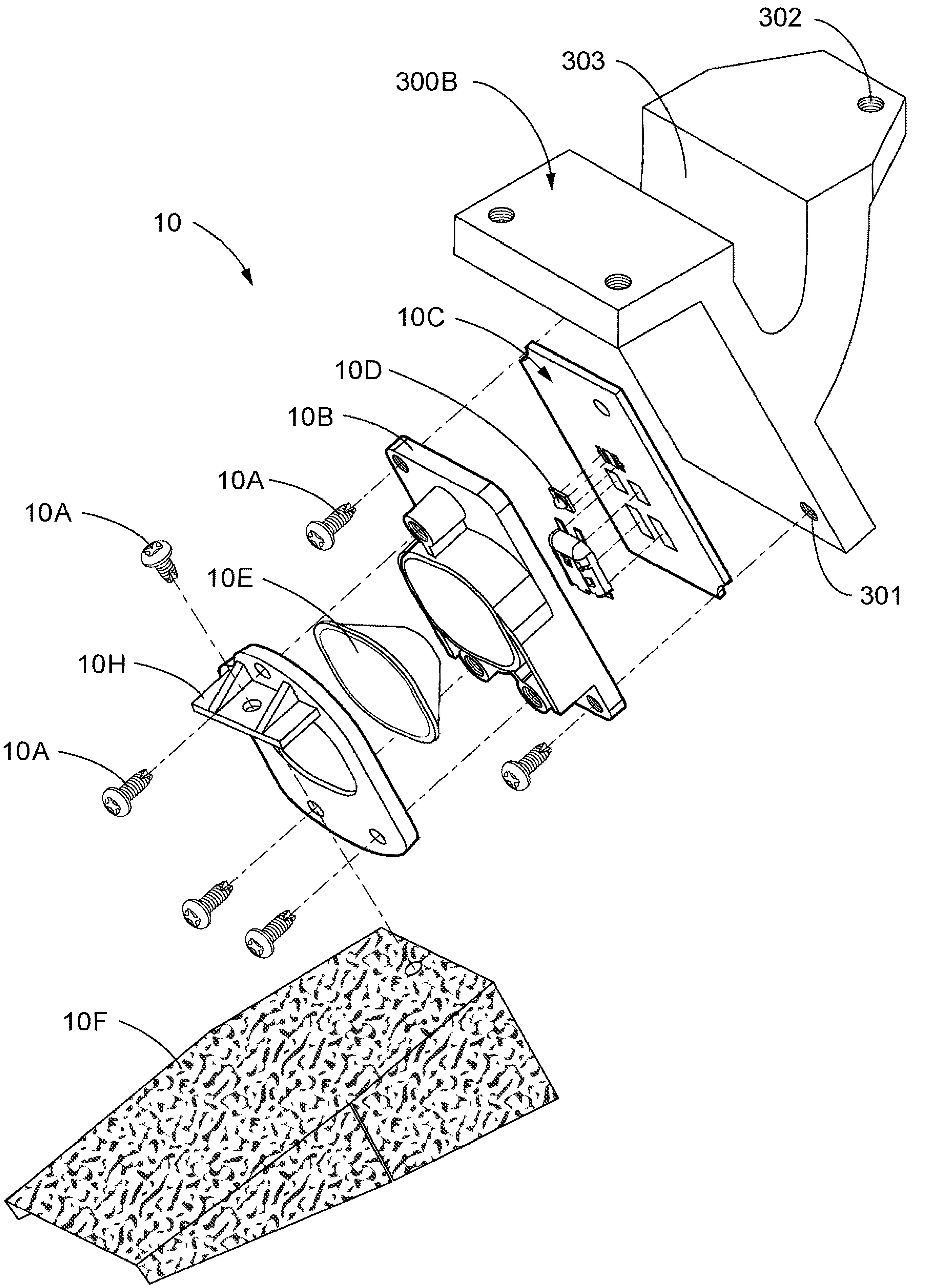

7000
7001
Determine initial water content in fixture
7002
Determine initial water content in devices
7003
Determine water content for ambient conditions
7004
Calculate needed desiccant for fixture life (new or remaining)

Figure 16



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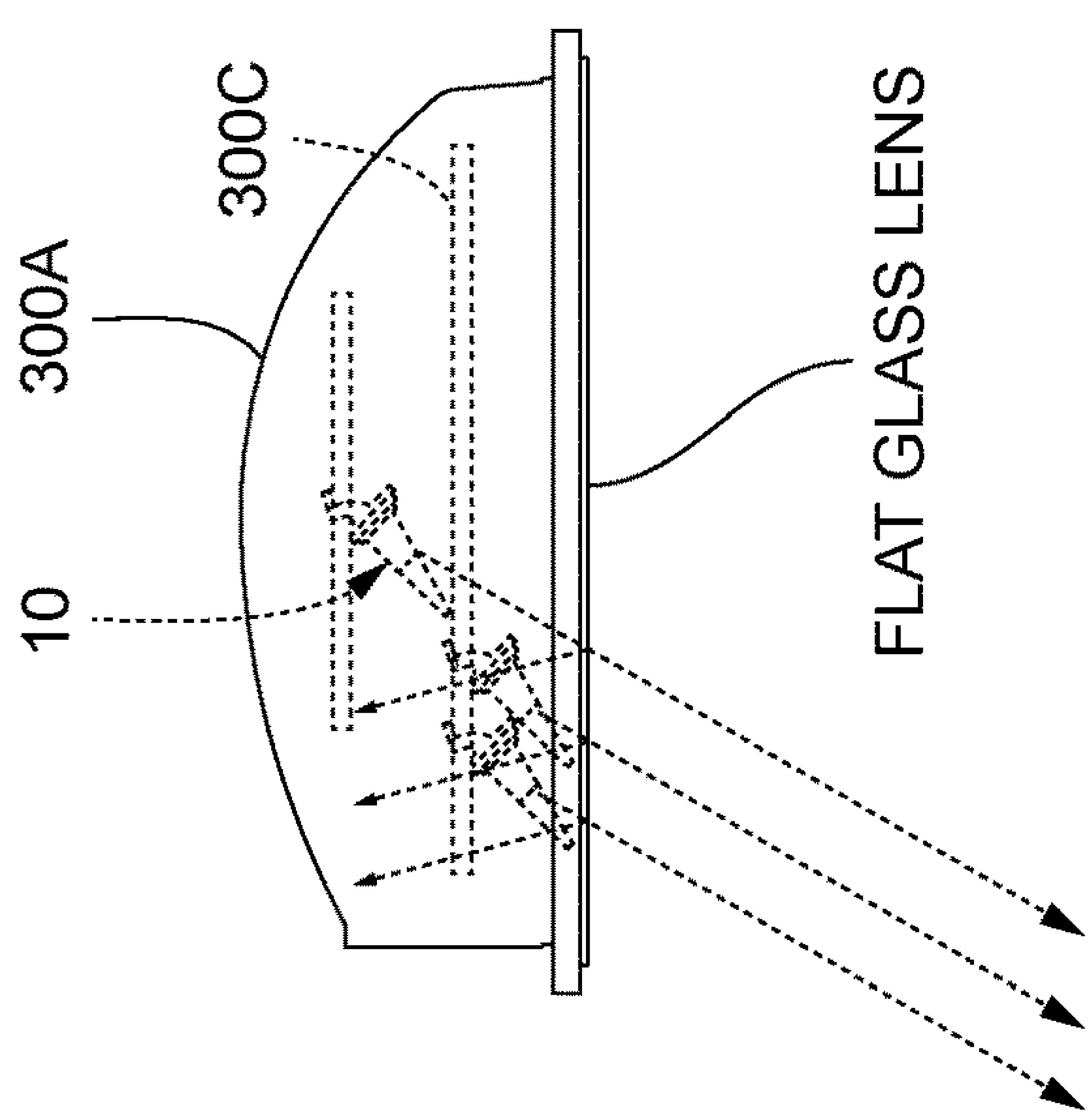

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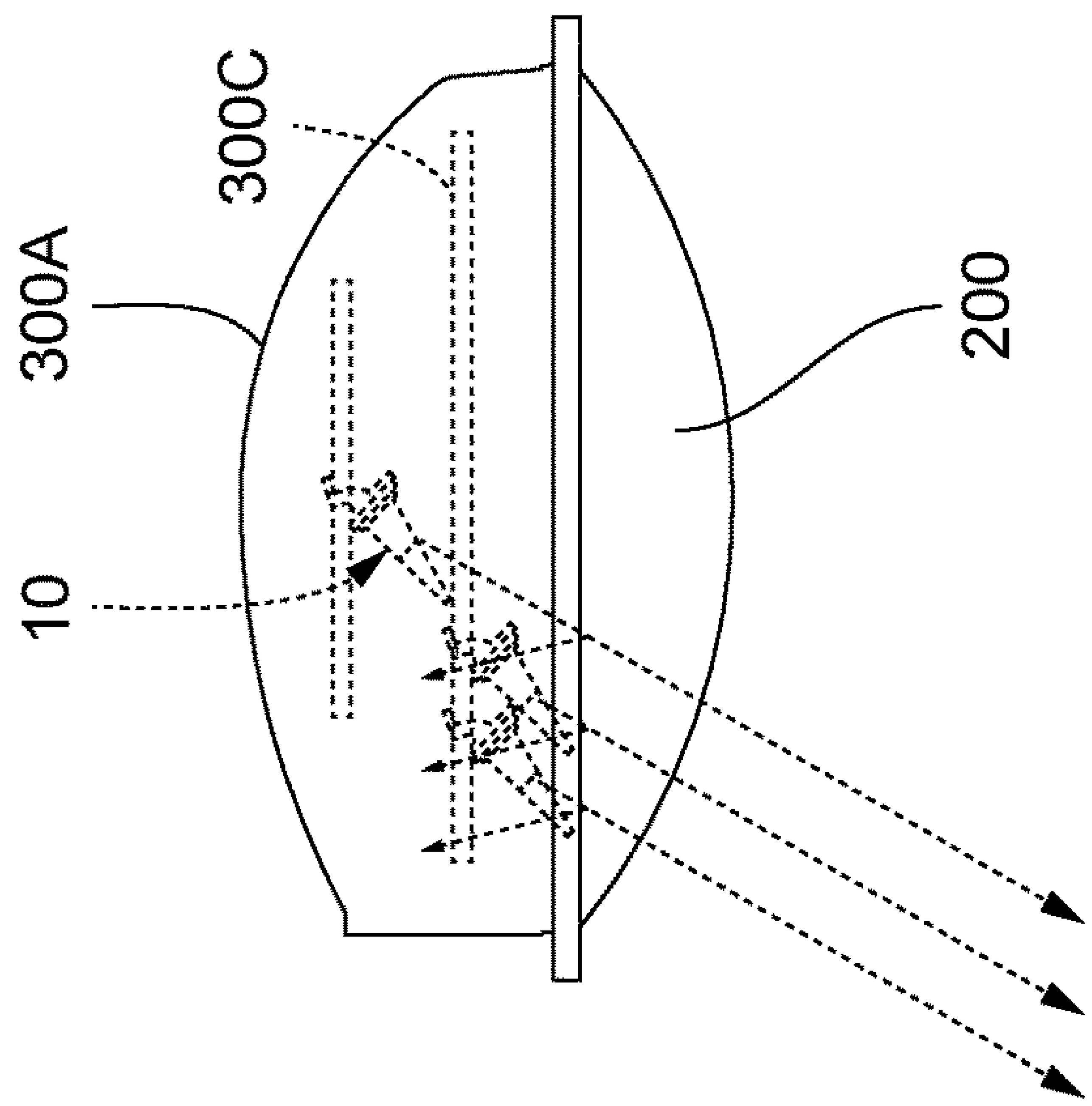

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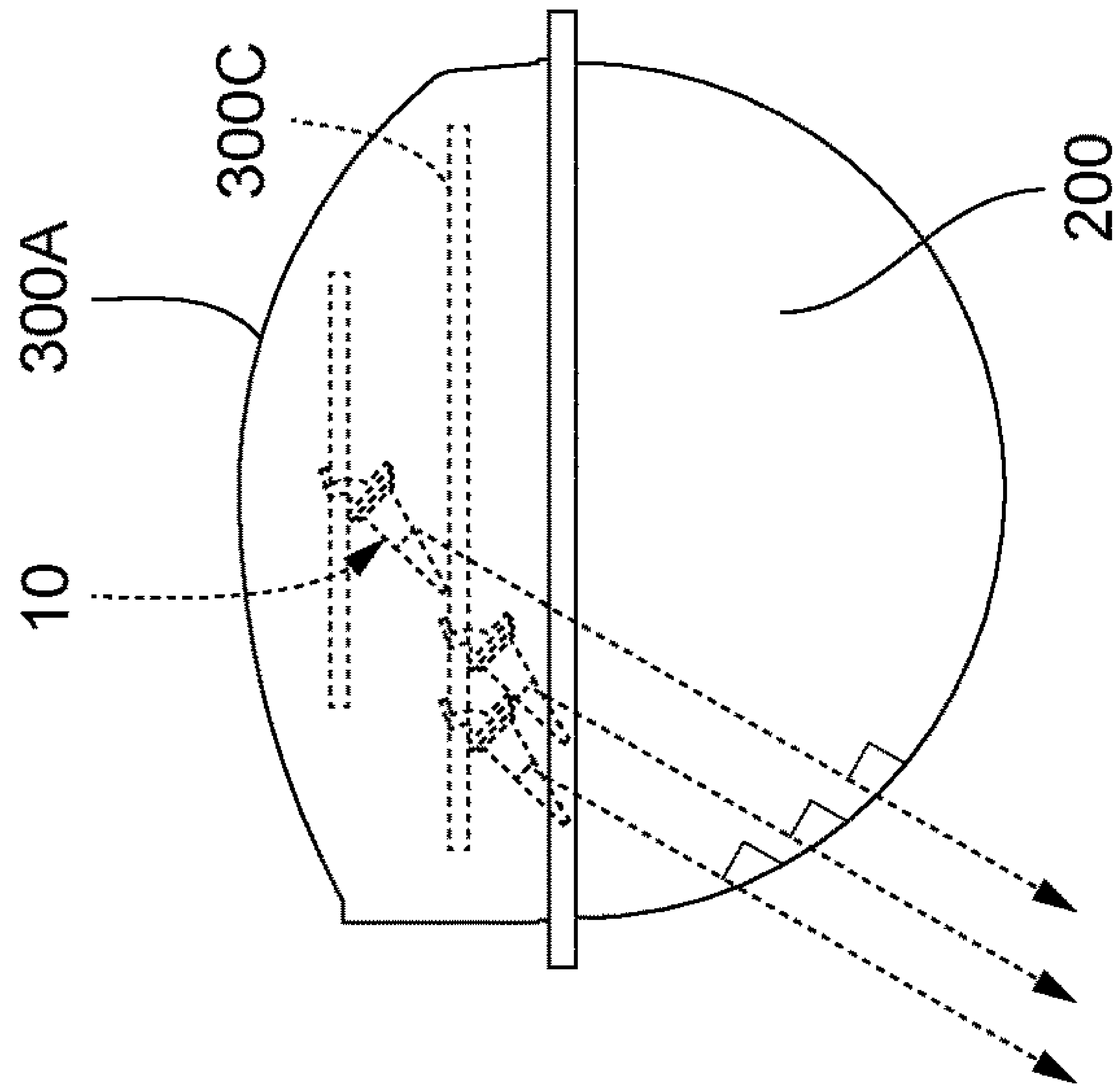

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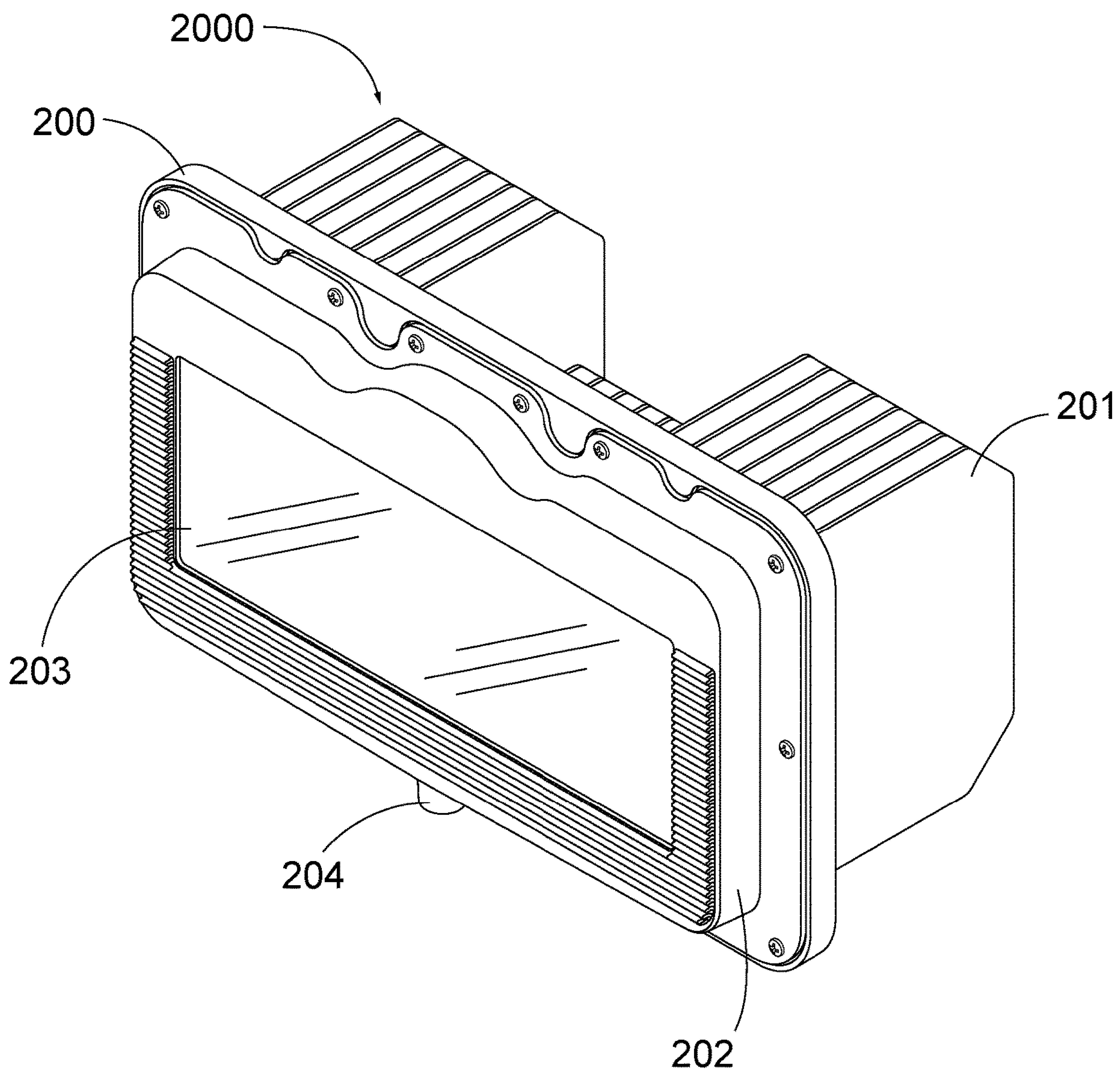

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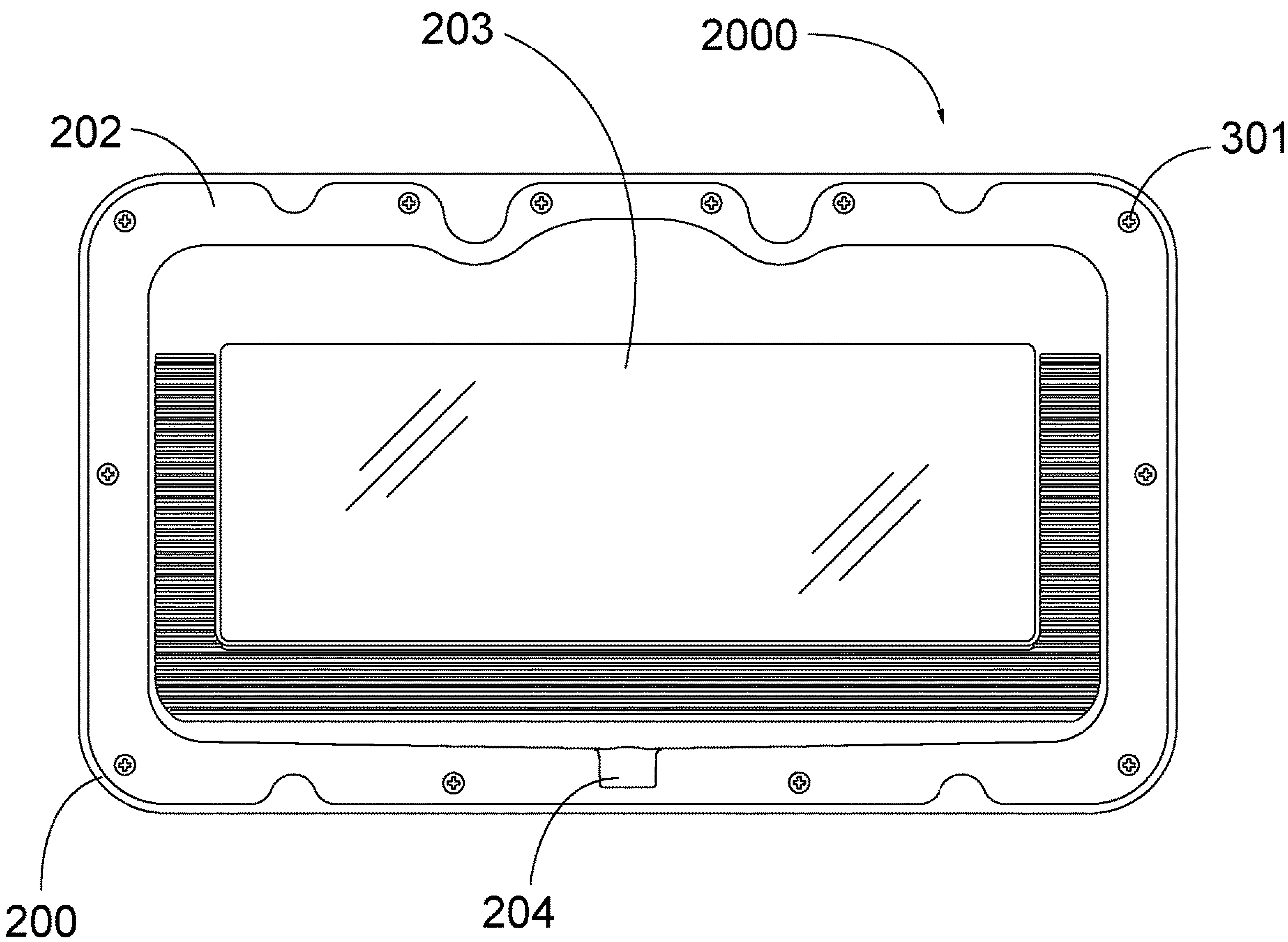

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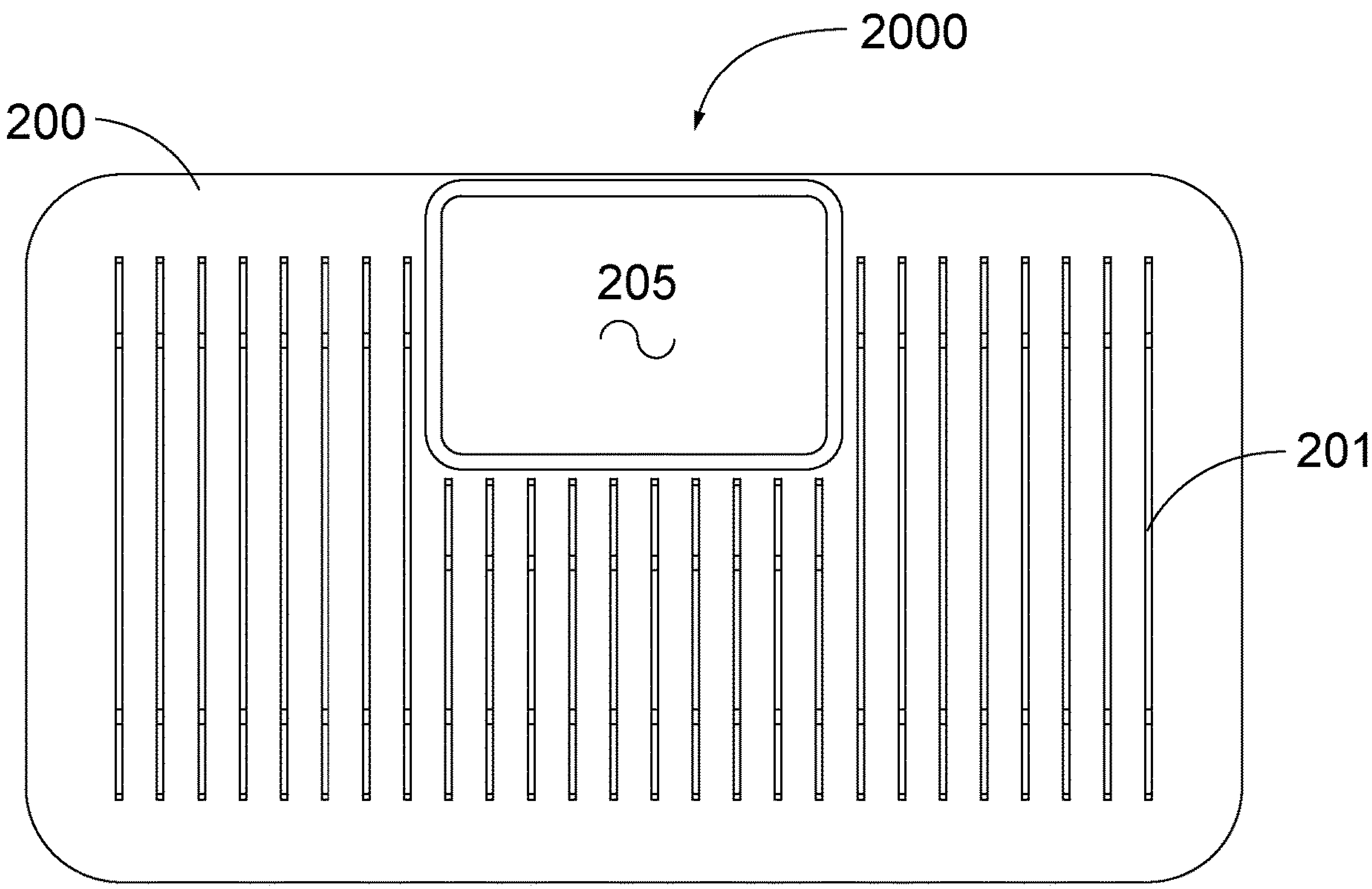

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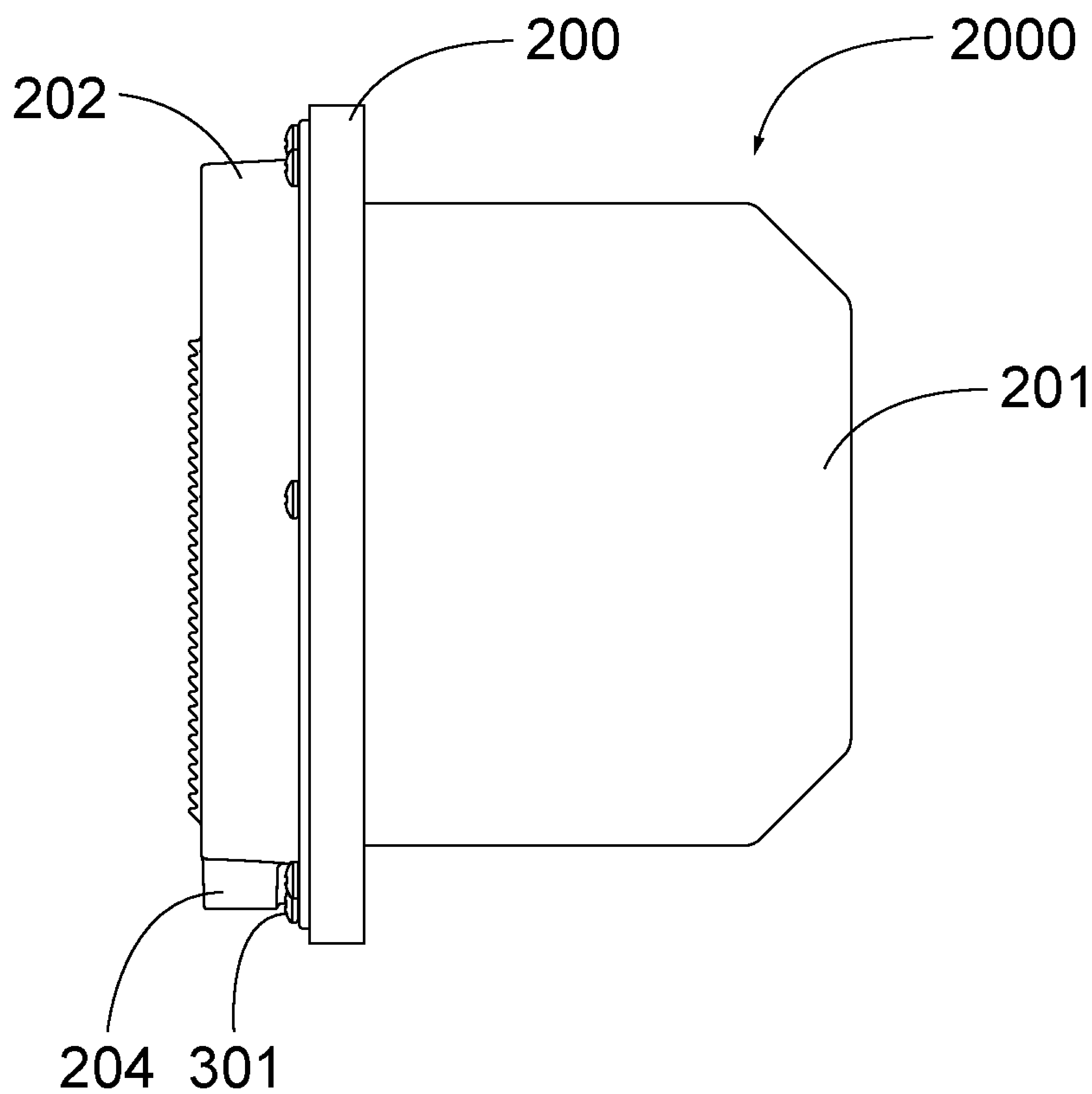

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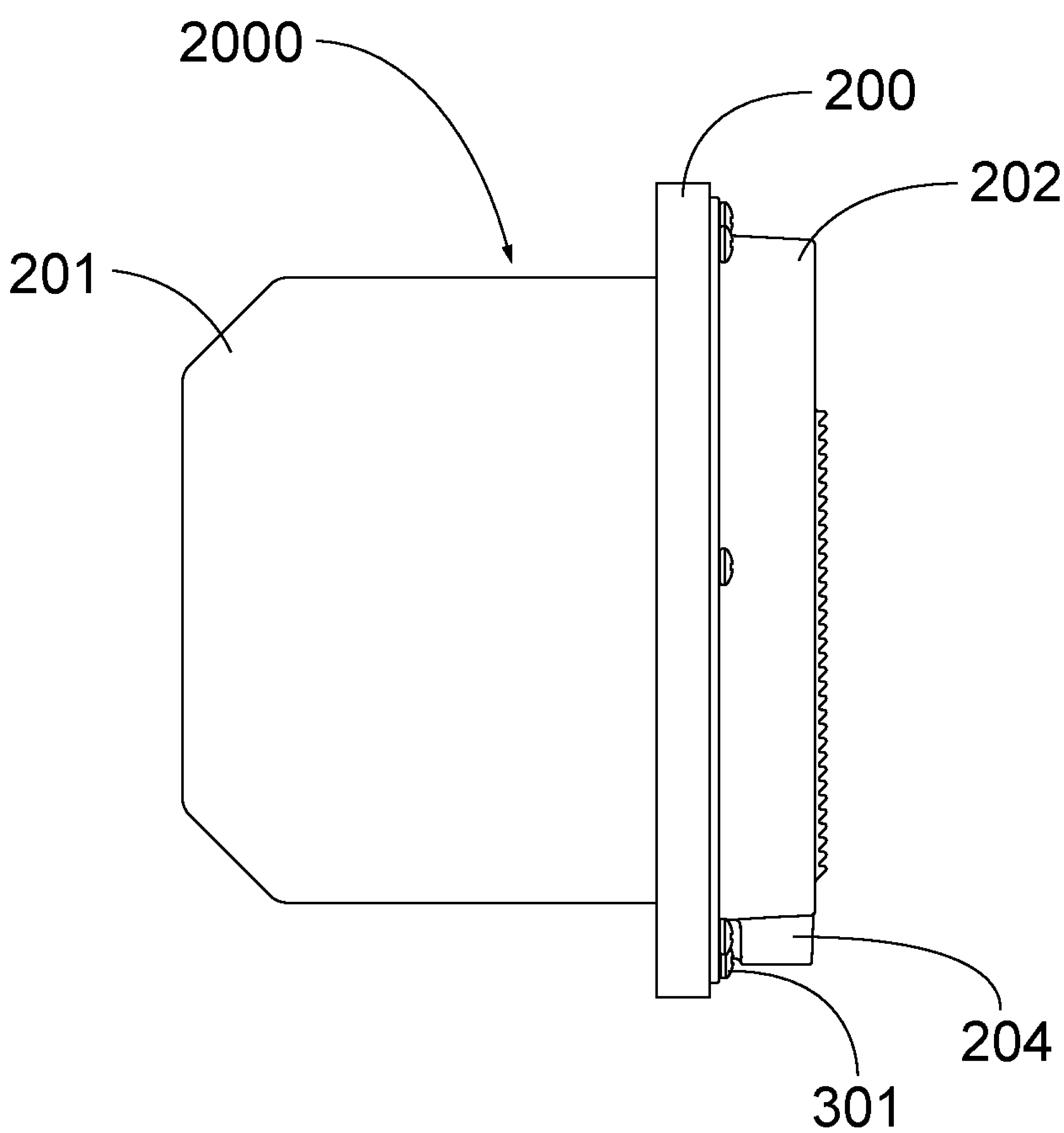

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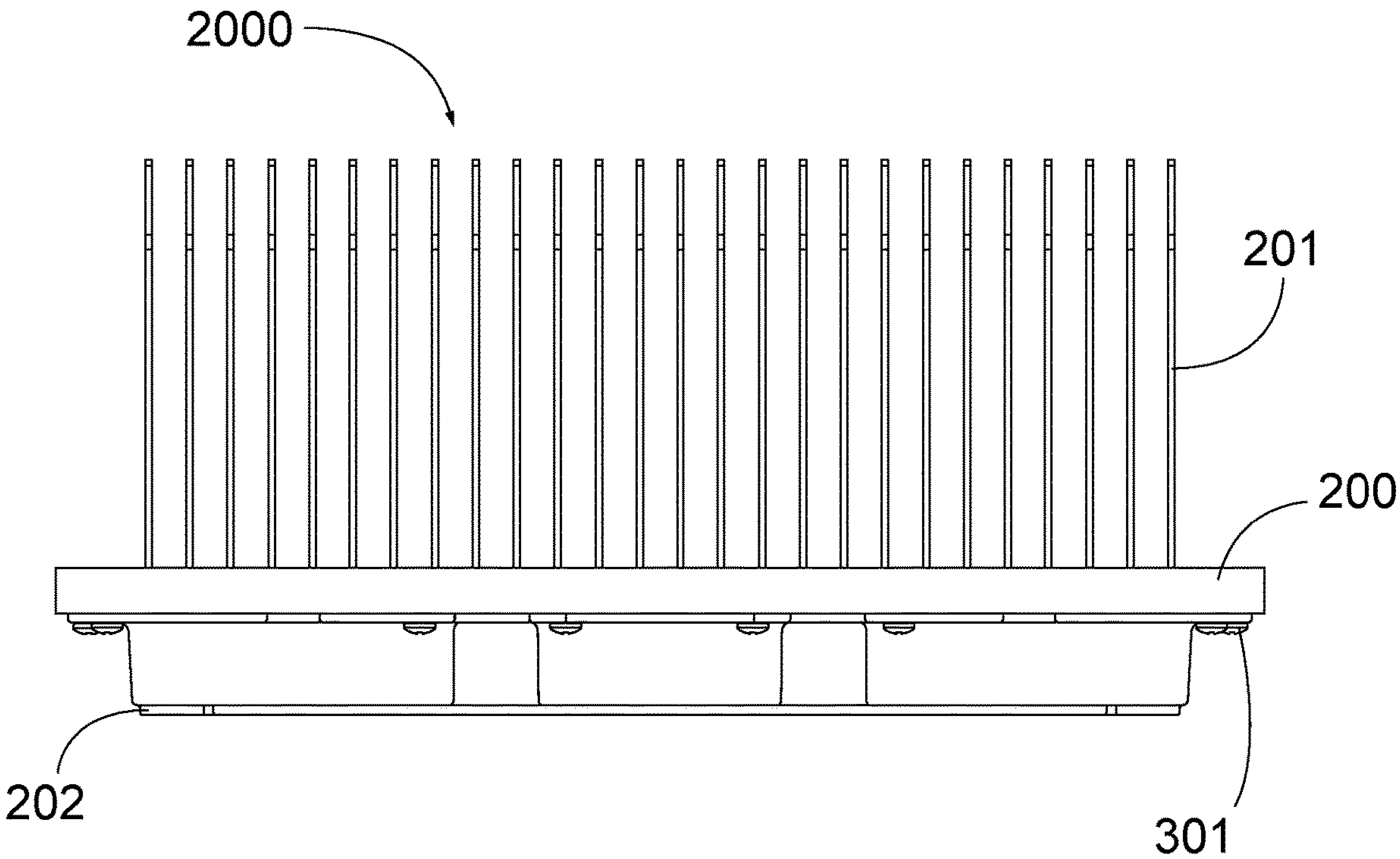

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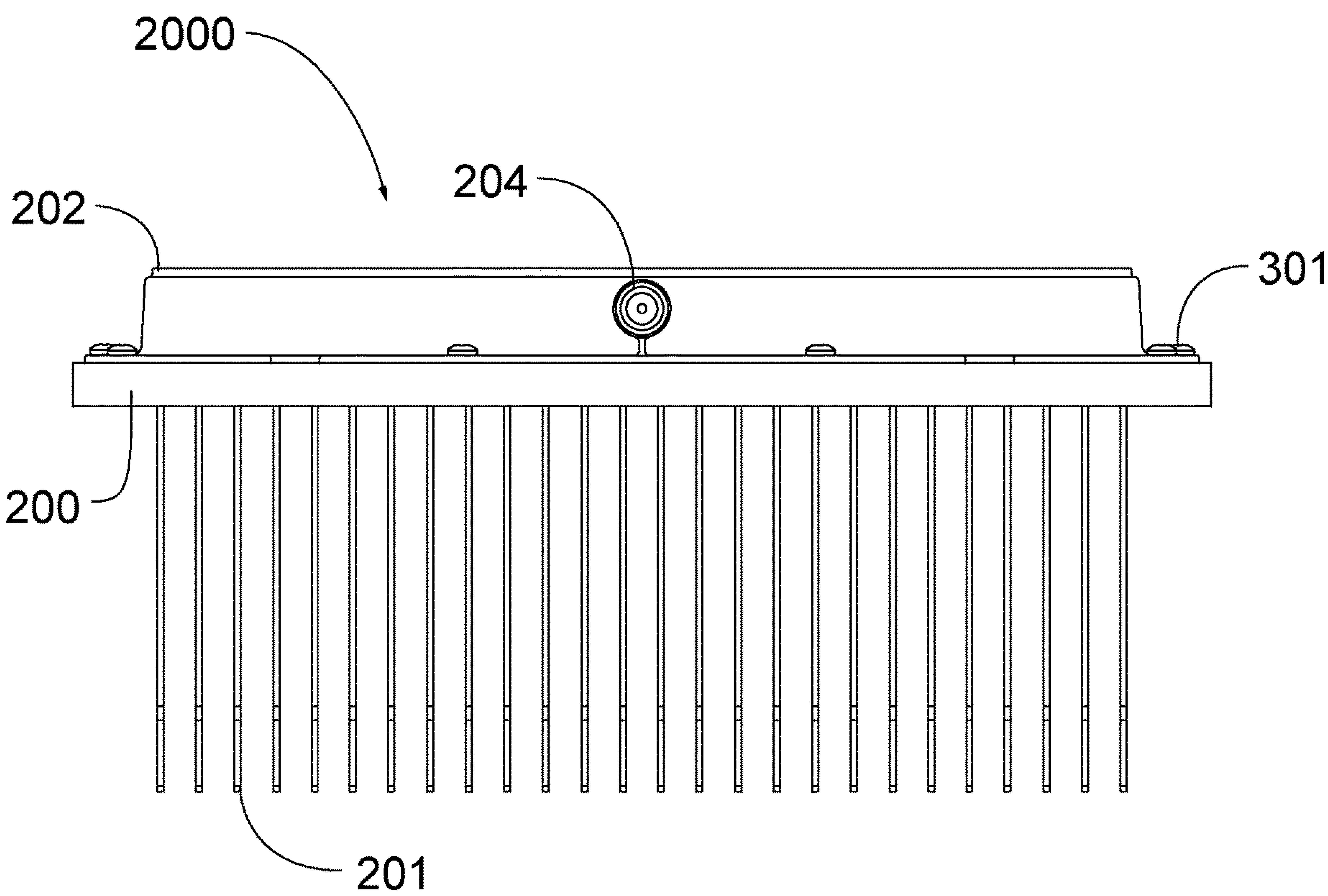

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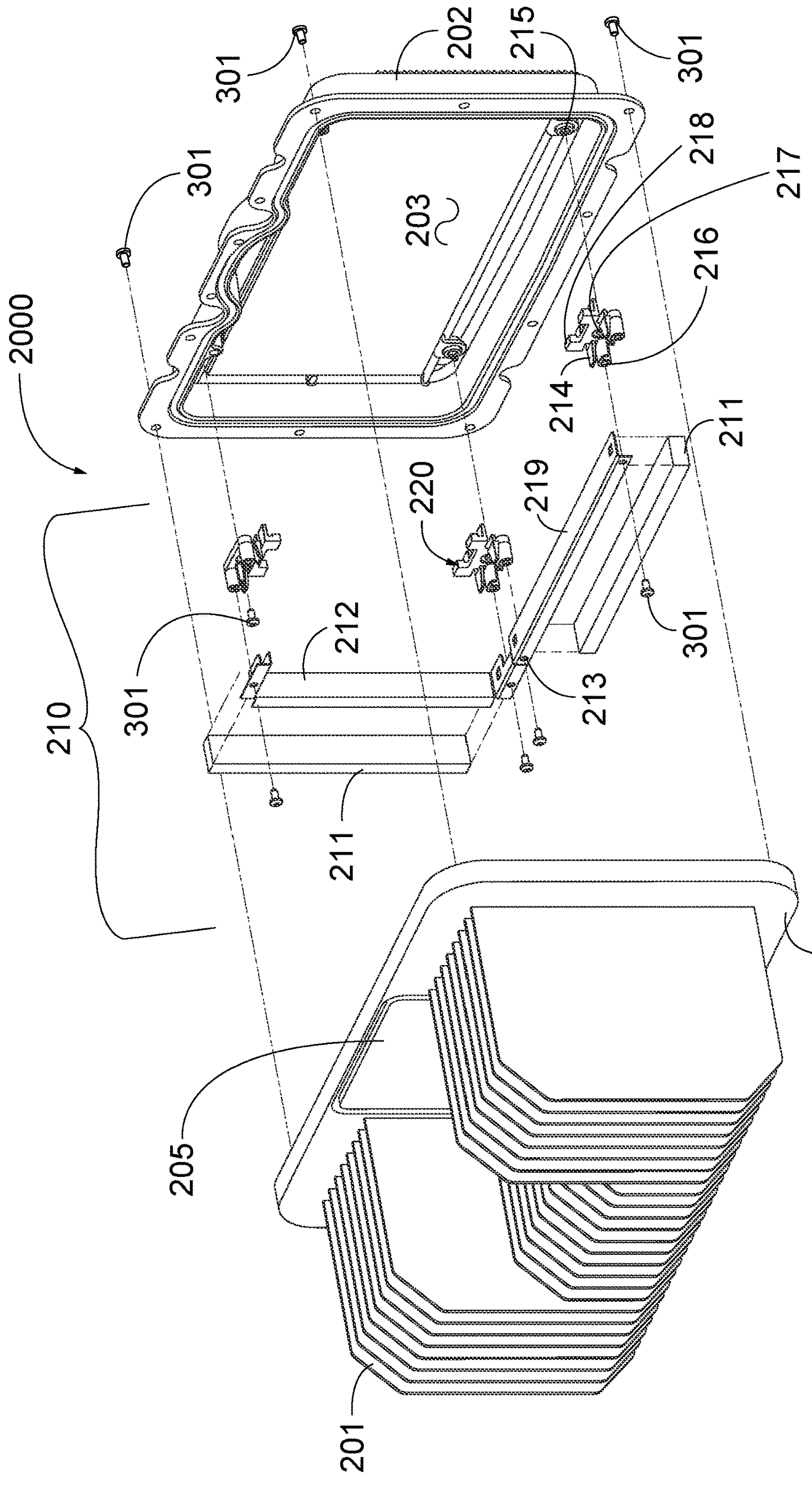
2000
210
301
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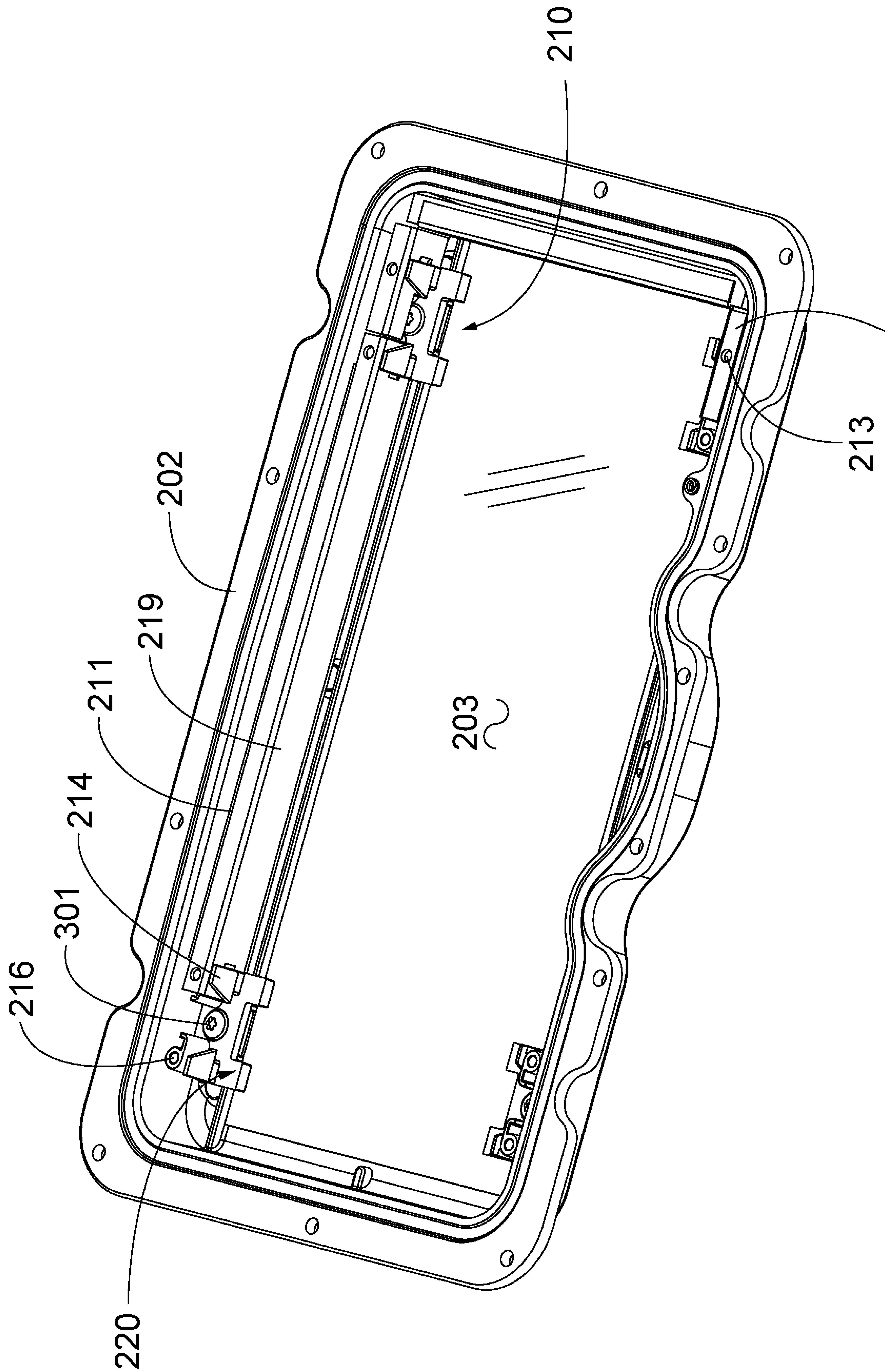
205
200
201
Figure 26



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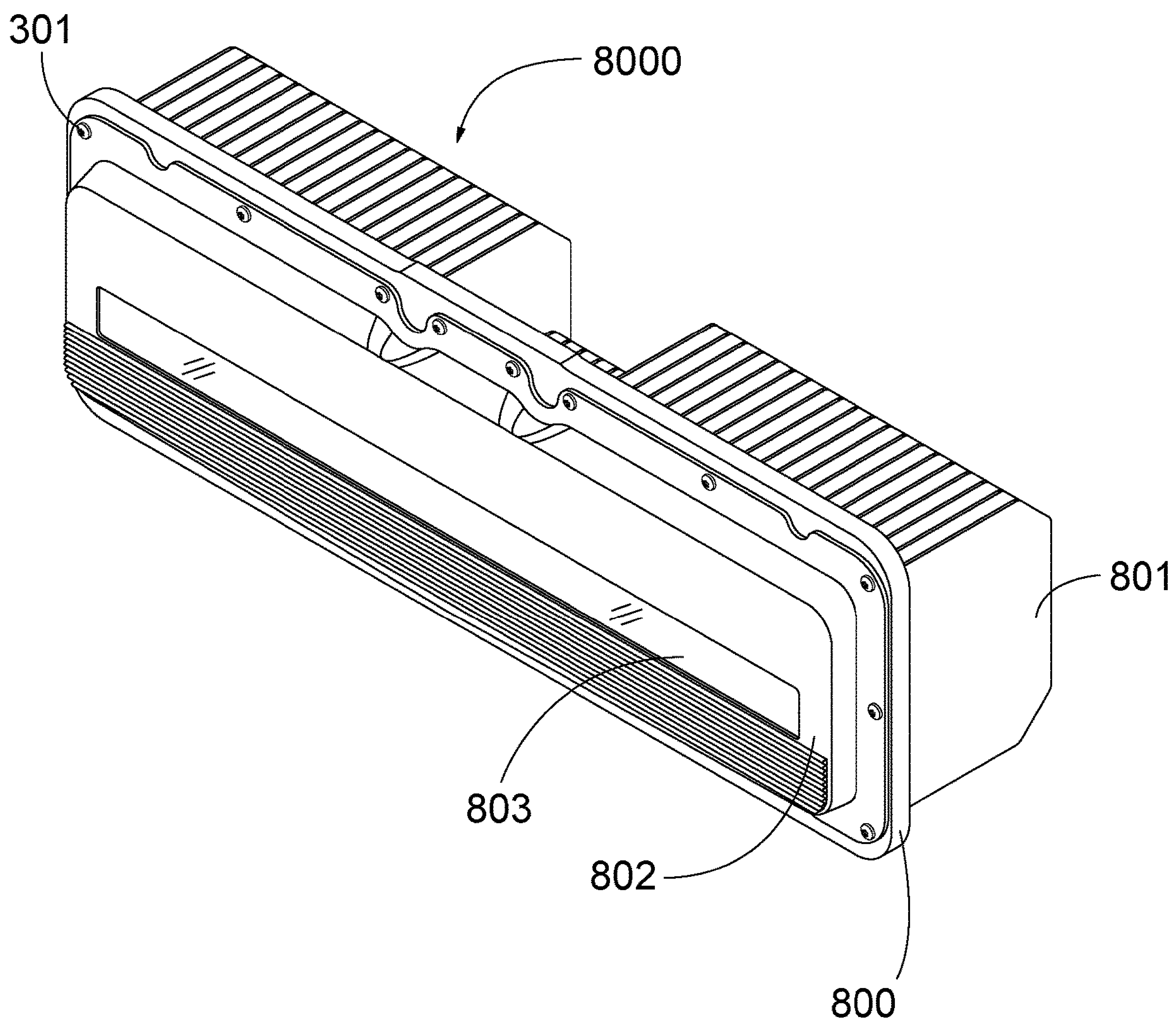

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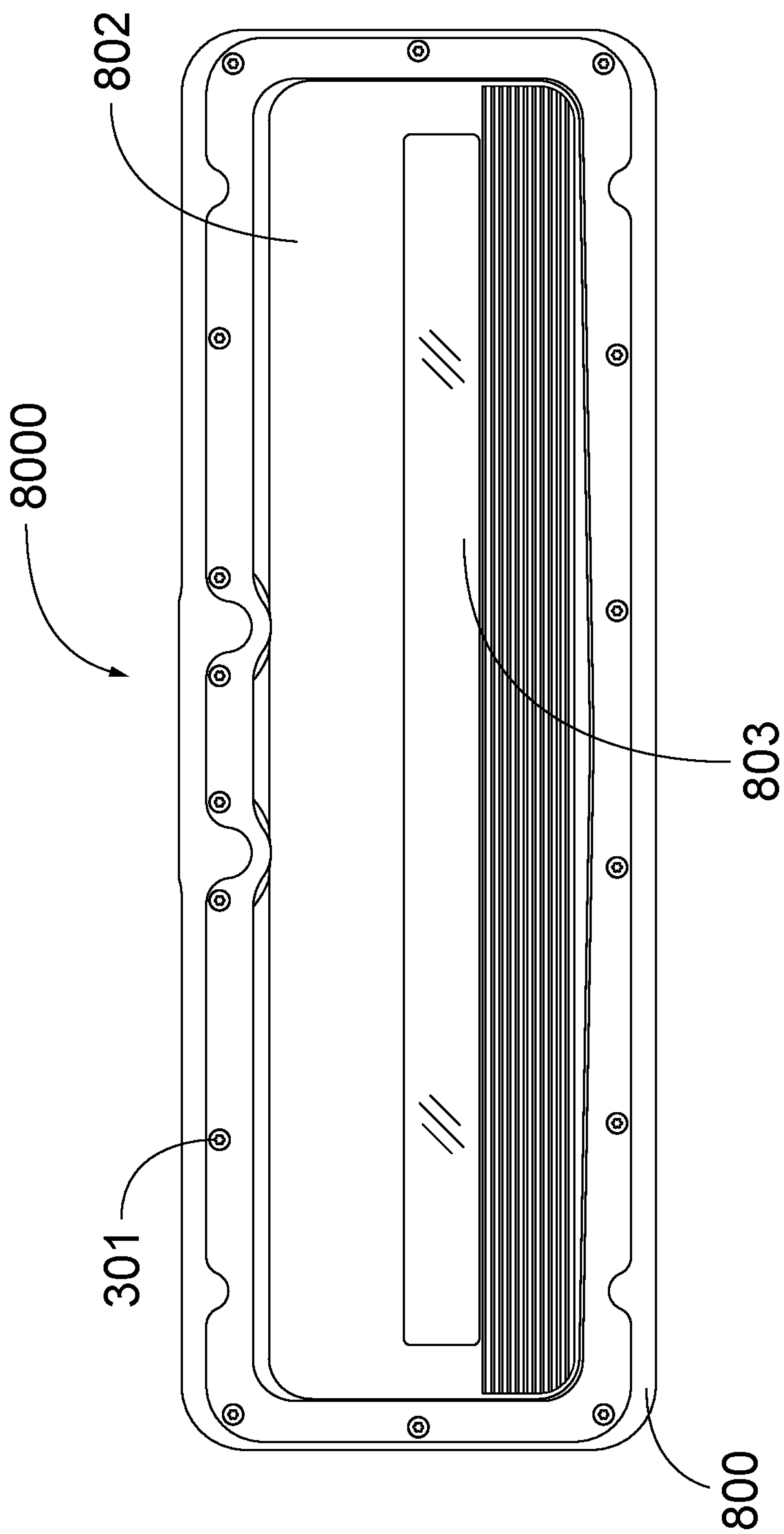

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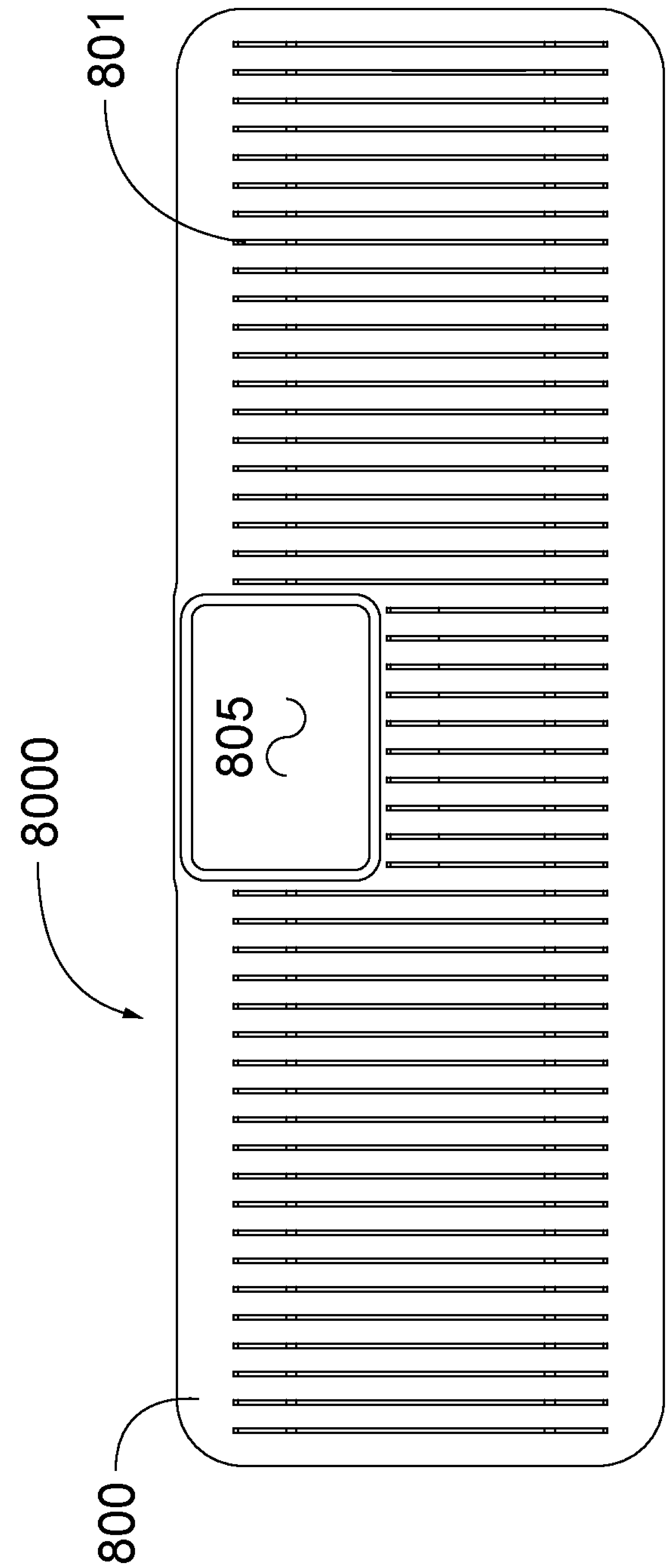

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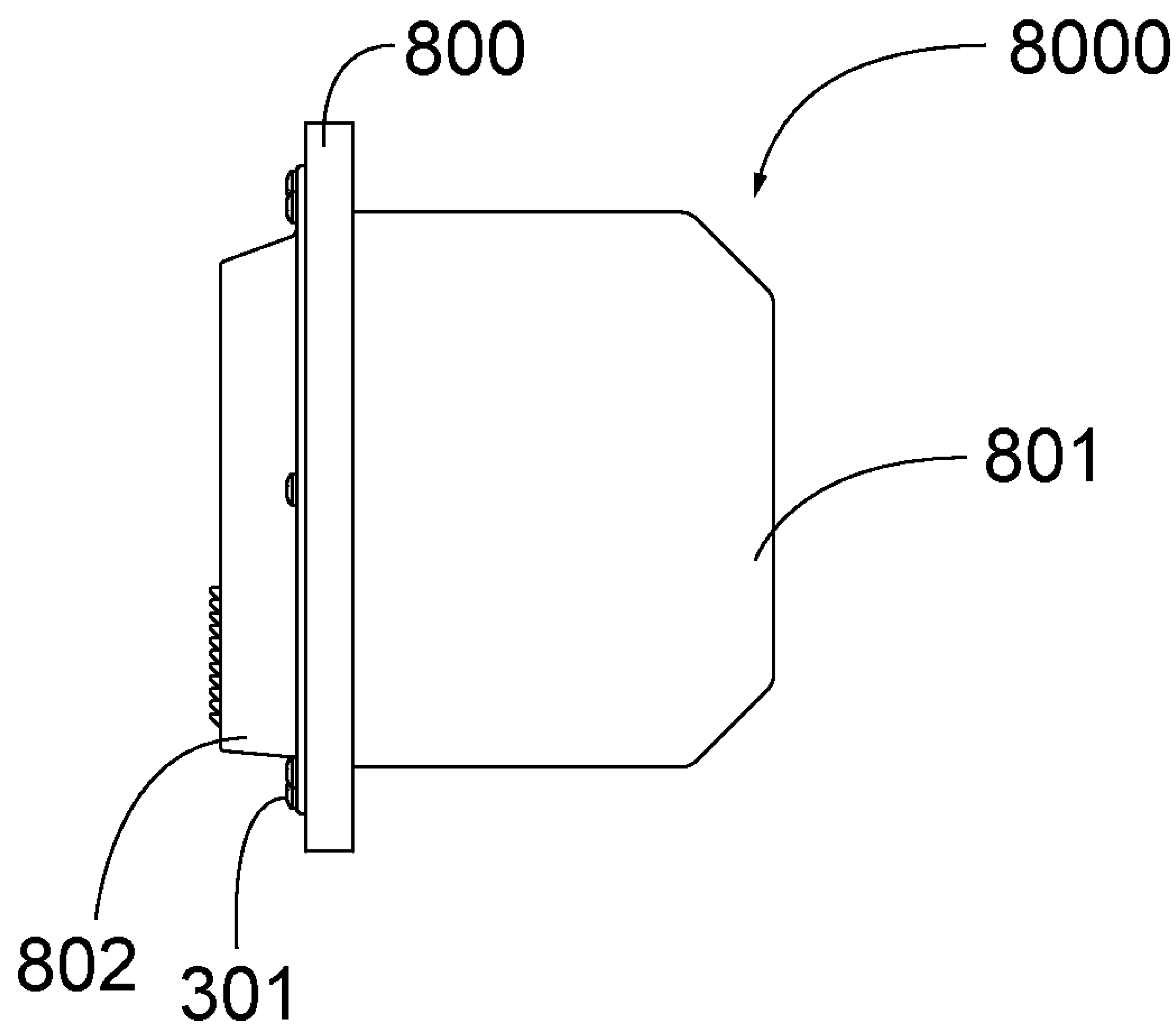

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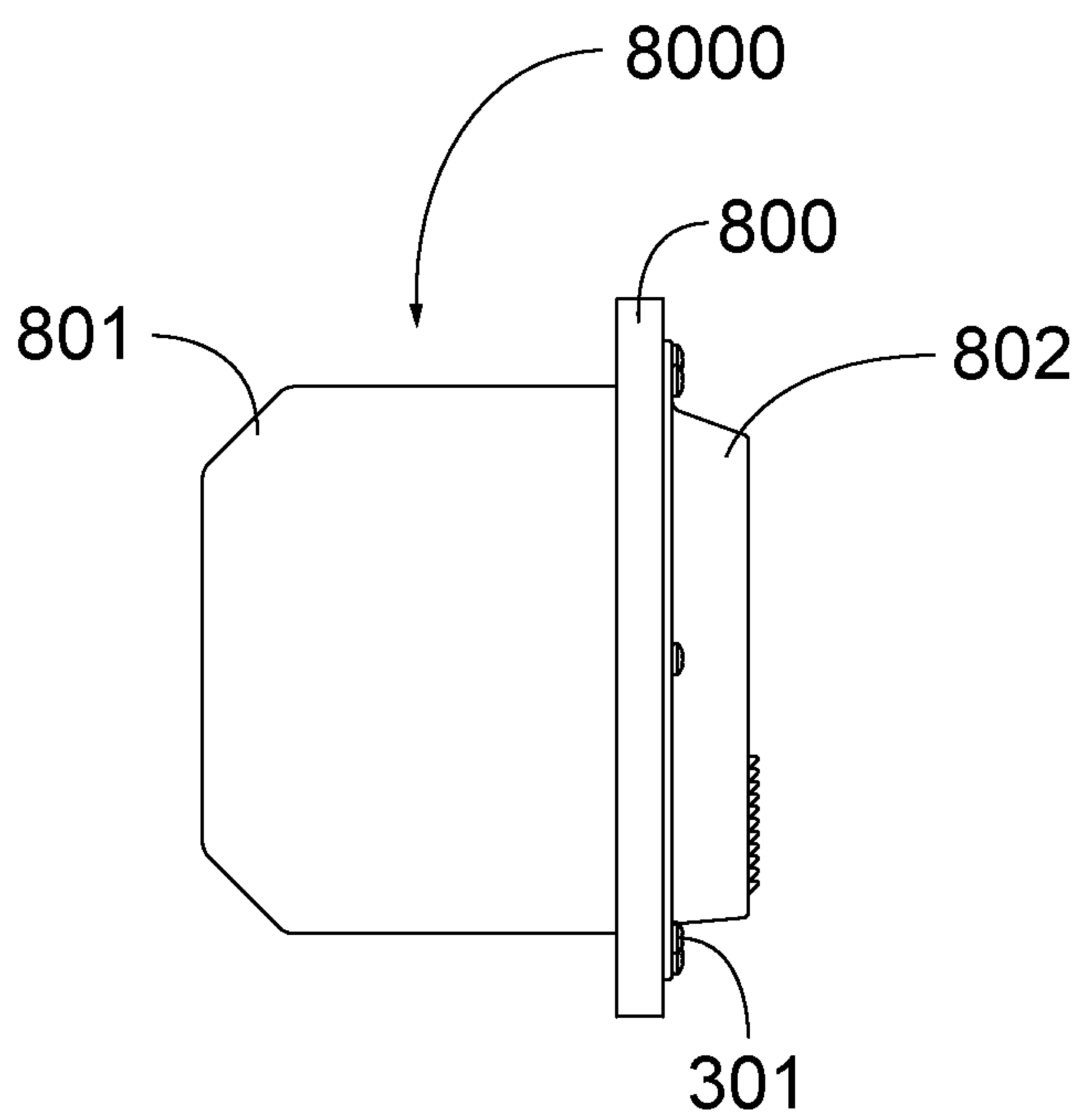

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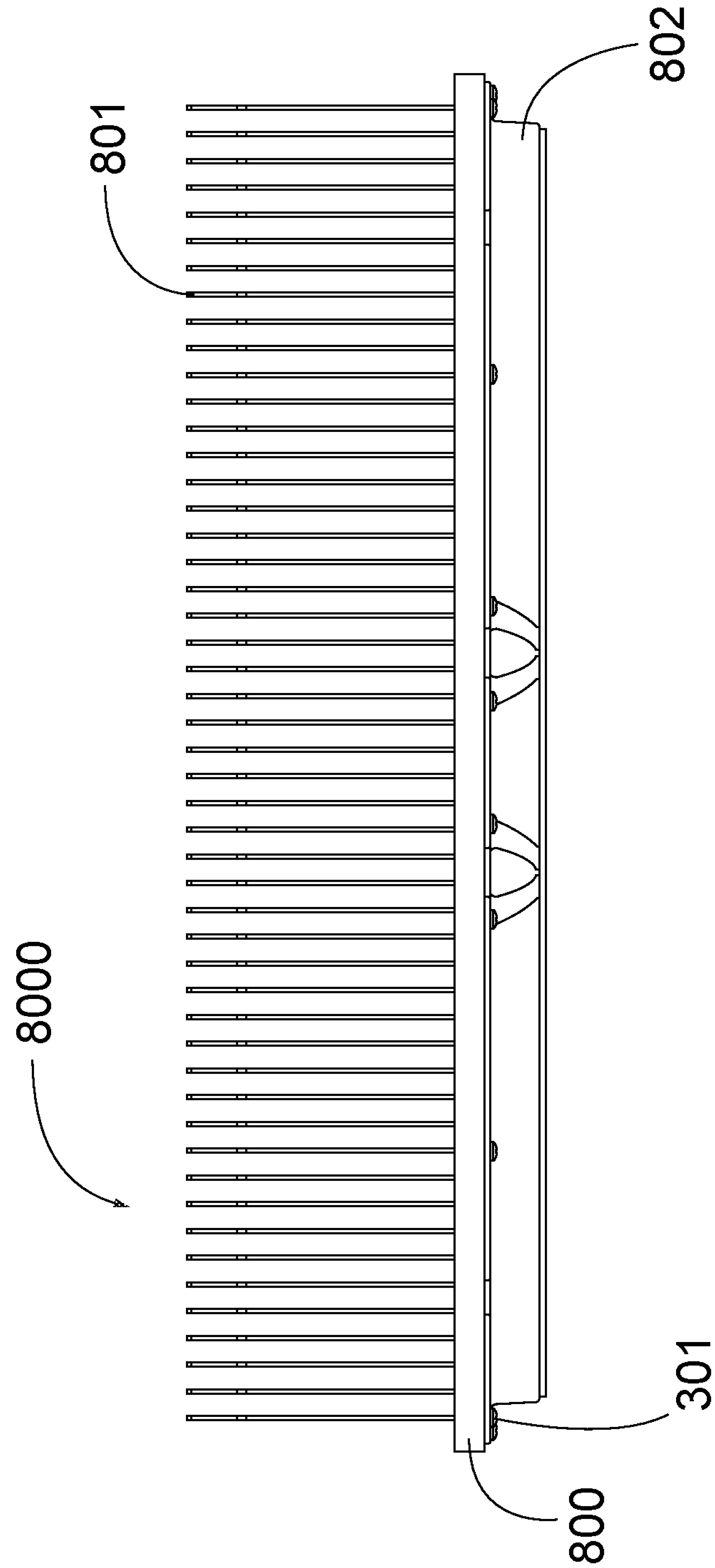

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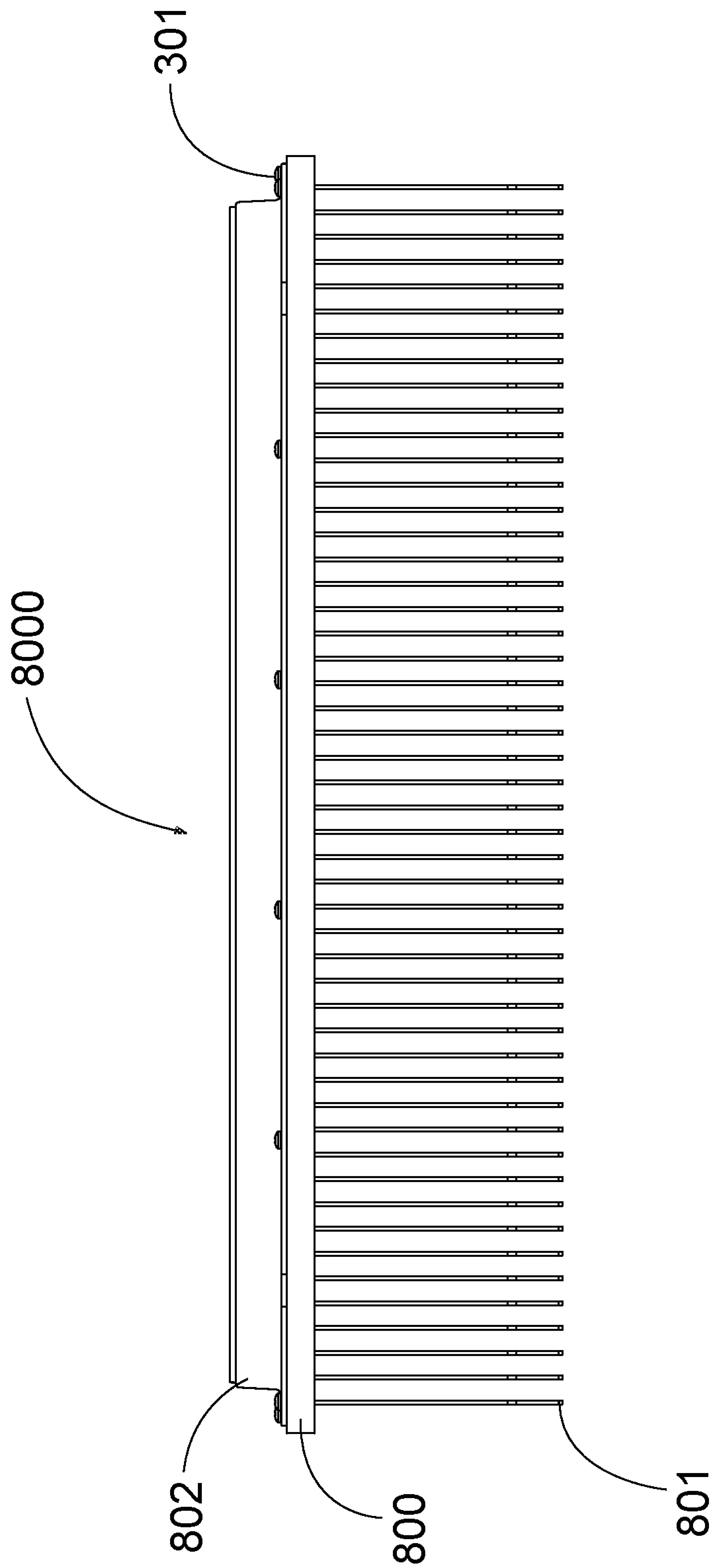

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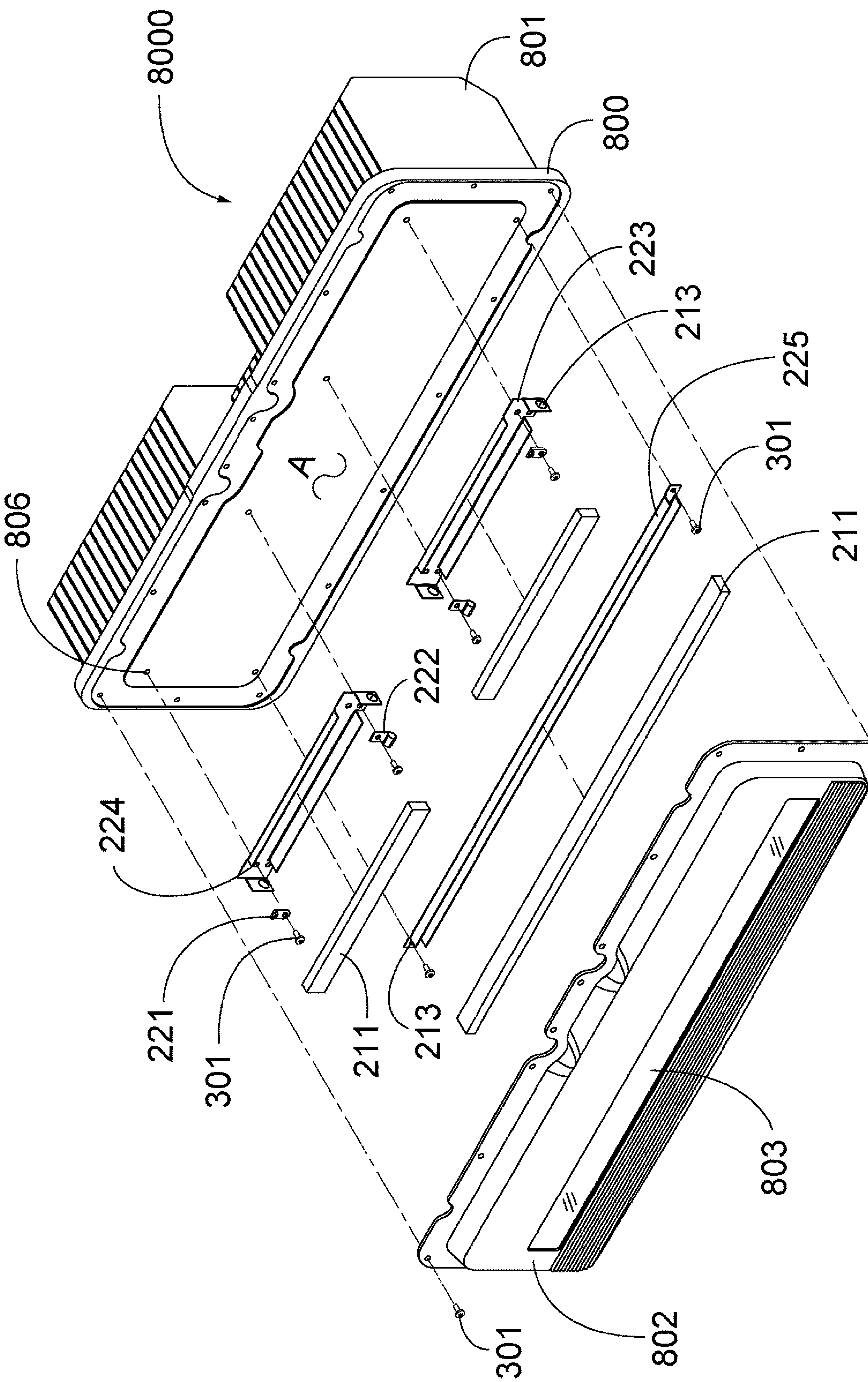
8000
801
800
223
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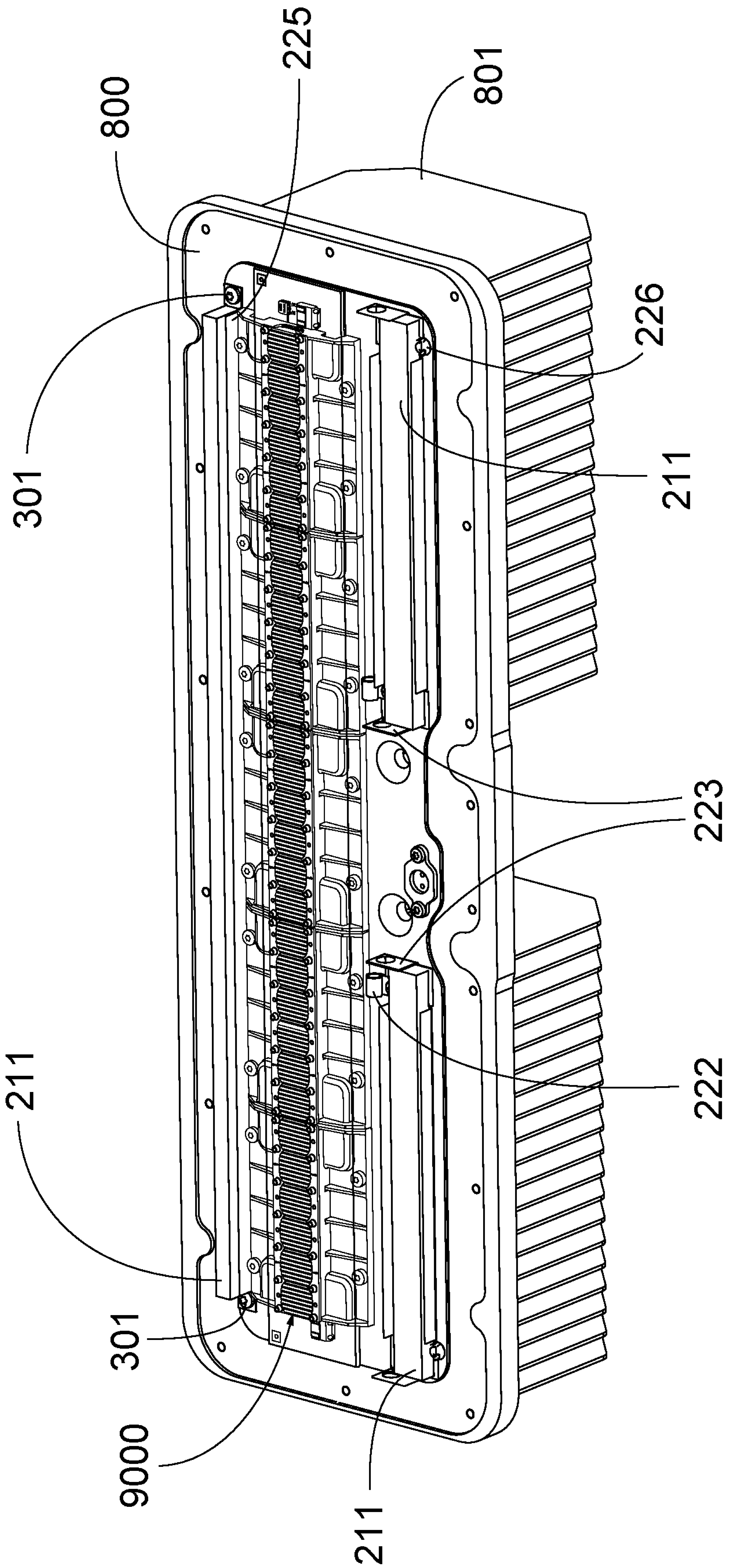
225
301
211
806
A
222
224
221
301
211
213
803
301
802
301

Figure 35



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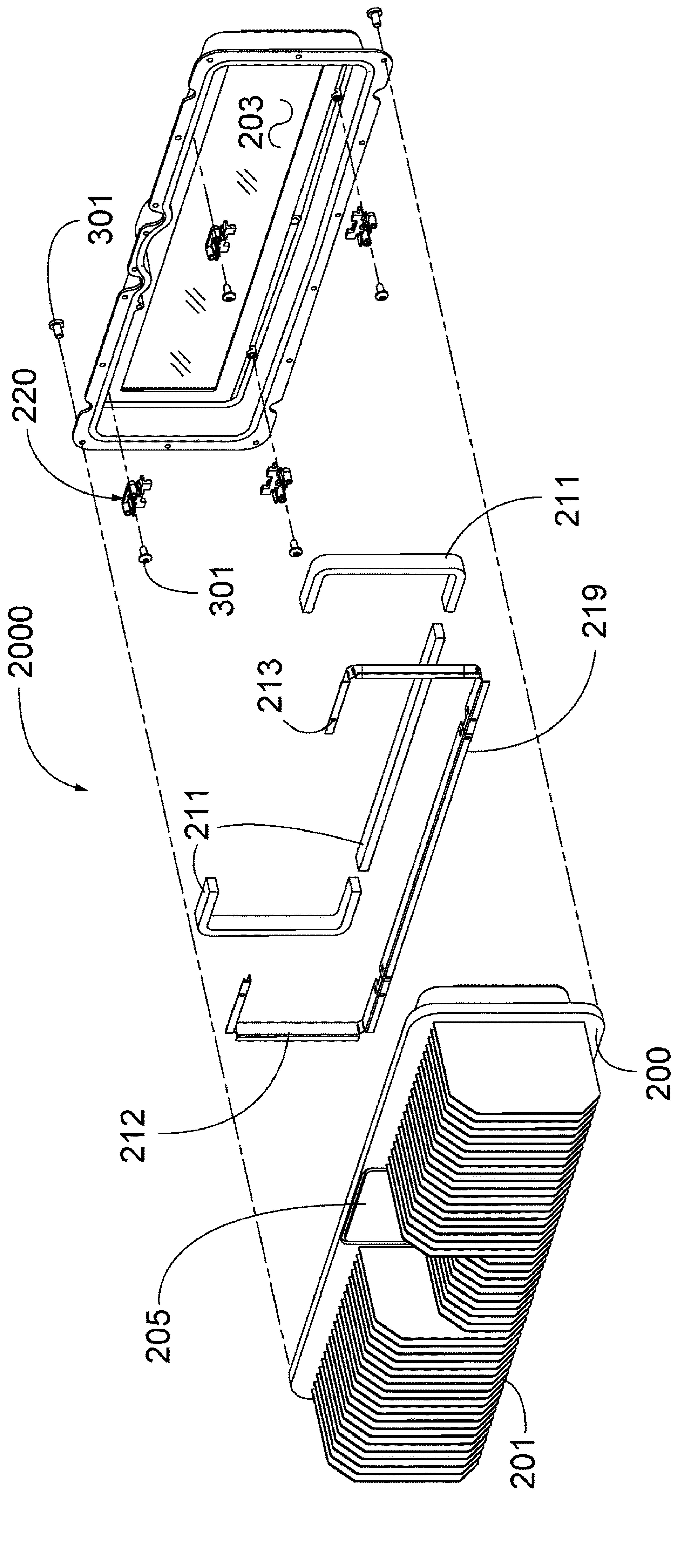

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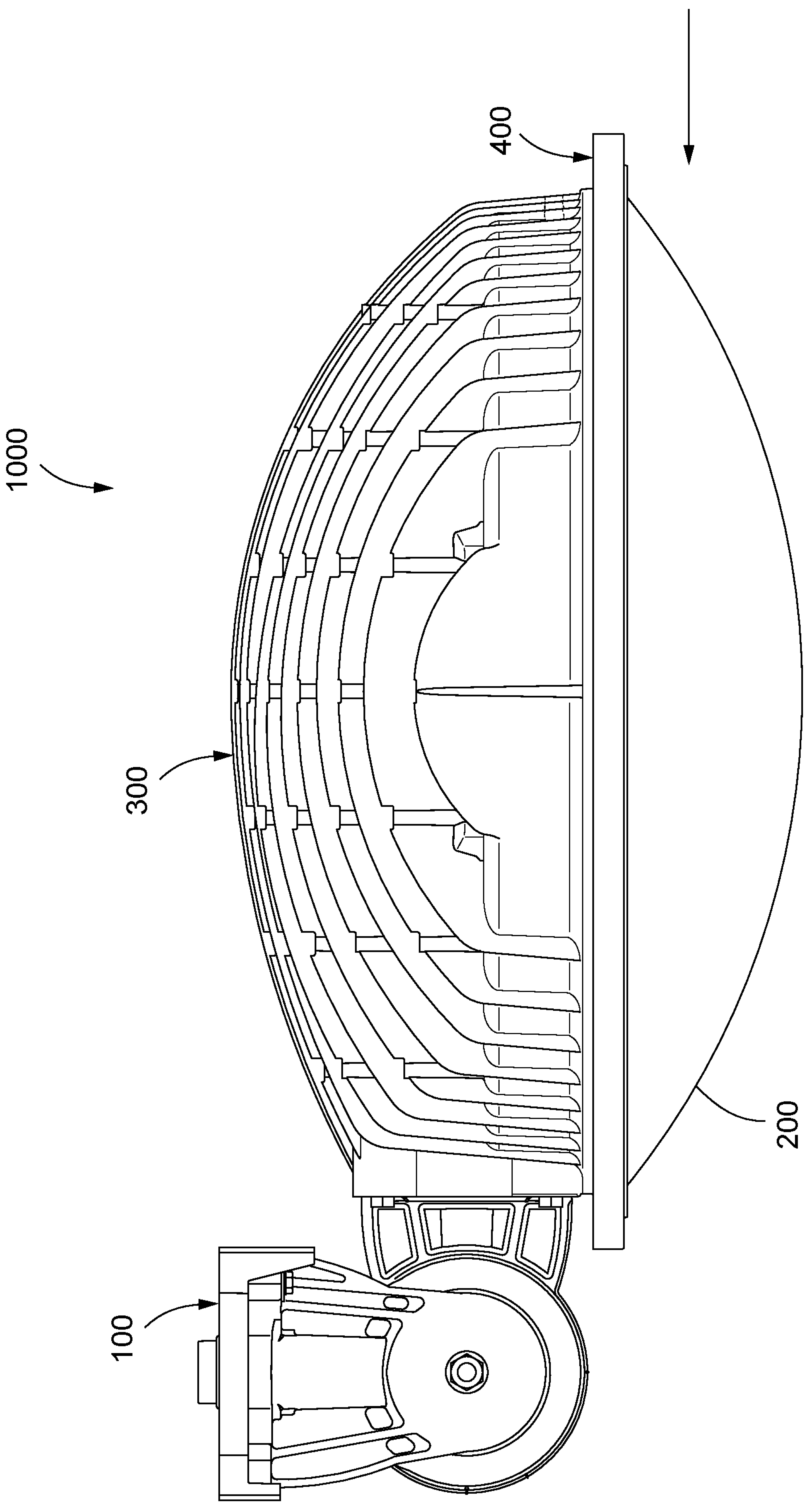

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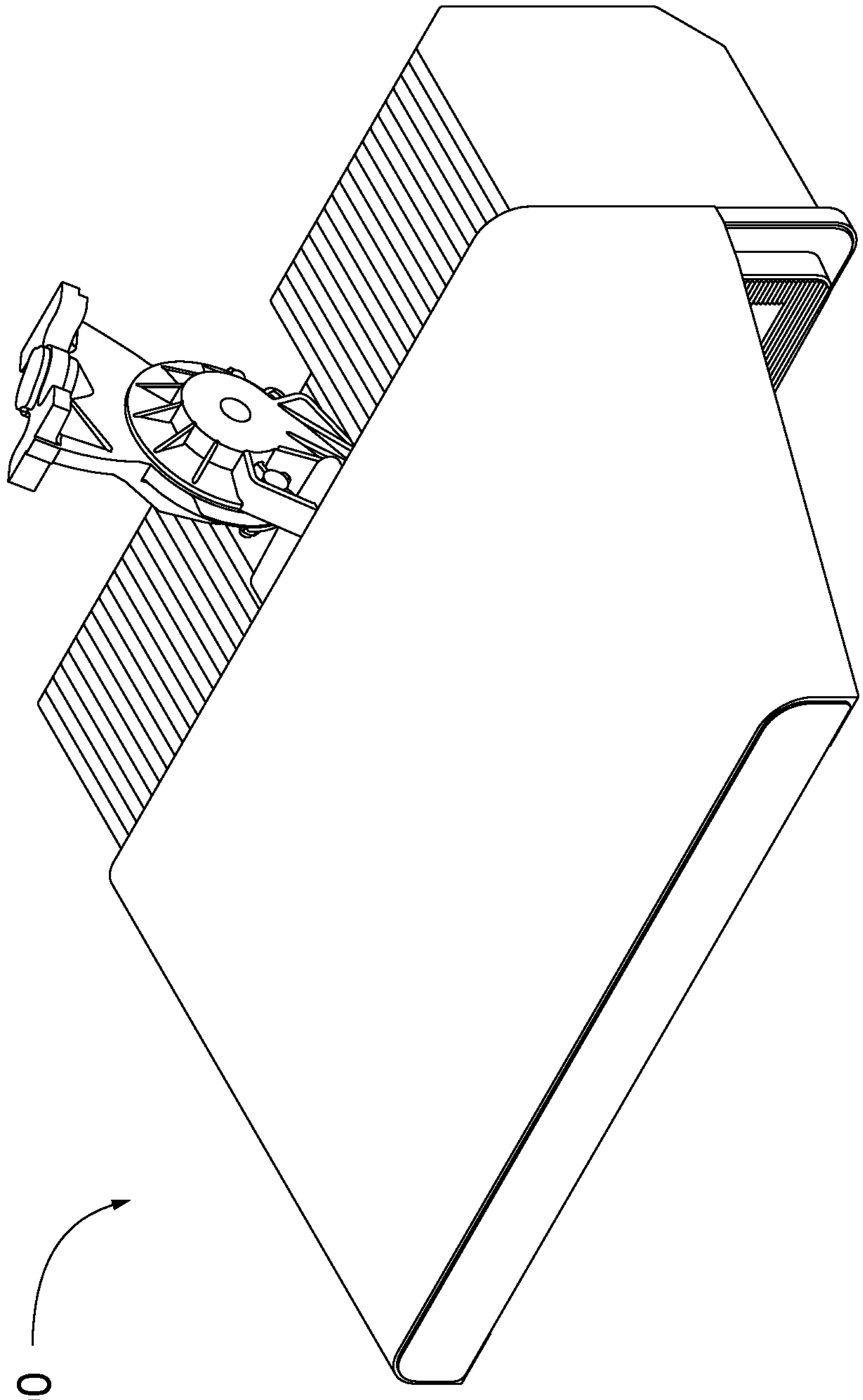
10000

Figure 39

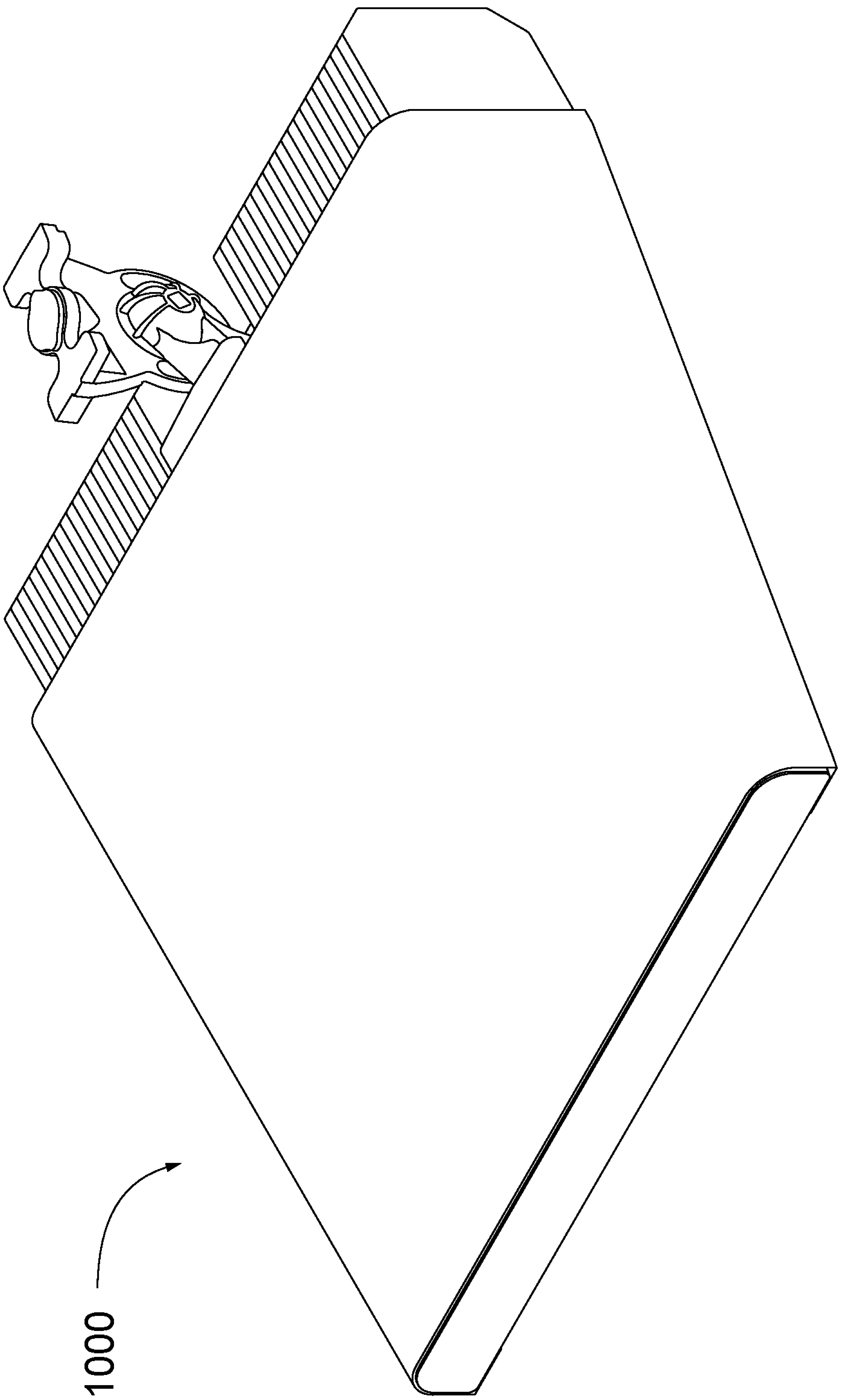

Figure 40

APPARATUS, METHOD, AND SYSTEM FOR REDUCING MOISTURE IN LED LIGHTING FIXTURES

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. application Ser. No. 16/741,049, filed Jan. 13, 2020, which claims priority under 35 U.S.C. § 119 to provisional U.S. application Ser. No. 62/791,941, filed Jan. 14, 2019, and provisional U.S. application Ser. No. 62/799,281, filed Jan. 31, 2019, all of which are hereby incorporated by reference in their entireties.

I. TECHNICAL FIELD OF INVENTION

The present invention generally relates to removing moisture from lighting fixtures. More specifically, the present invention relates to (i) in situ or field repairs of lighting fixtures which exhibit internal condensation under at least some conditions, and to (ii) apparatus, methods, and systems implemented in a factory setting so to avoid or minimize adverse impact from moisture in lighting fixtures.

II. BACKGROUND OF THE INVENTION

It is well known that lighting fixtures are designed to not only produce light, but produce useful light; namely, light harnessed and directed in a manner so to provide lighting for a task (or otherwise desired). For the example of sports lighting, lighting fixtures are mounted high above a field or other target area, aimed generally towards some portion of the field (or space above the field) at both a horizontal and vertical angle sufficient to light the target area but not so severe as to cause glare along common player lines of sight. The light projected from each fixture in an array of such elevated and aimed fixtures is specifically designed to provide a beam of particular dimensions and intensity. In this manner, lighting specifications are met by layering a number of these beams from a number of elevated lighting fixtures so to create a composite beam. So it can be seen that misalignment of any of the many lighting fixtures in an array can adversely impact the composite beam, and by extension, cause a failure in meeting specifications. However, the same undesirable outcome can be produced when the light emitted from any of the many lighting fixtures is adversely impacted such that the individual beam is not of the desired dimensions and intensity.

Lighting fixtures such as the aforementioned rely on a number of different light directing devices (e.g., secondary lenses) and light redirecting devices (e.g., reflectors) to harness the light emitted from the light sources (e.g., a plurality of LEDs) and shape/direct it into light which is useful for an application. Light directing devices and light redirecting devices may be installed in a lighting fixture housing (e.g., proximate the light sources), outside a lighting fixture housing (e.g., proximate the emitting face of the lighting fixture housing), or both. Particularly for LEDs, it is not possible to produce useful light without employing a number of light directing and/or light redirecting devices.

Herein lies a problem. In the current state of the art, new models of LEDs are being developed that are more rugged, of higher efficacy, and can operate at higher temperatures; this requires in-kind development of light directing devices and light redirecting devices to realize these benefits. Transitioning to different materials in light directing and/or light redirecting devices for higher temperature purposes (e.g., switching from acrylic secondary lenses to higher operating temperature silicone secondary lenses) has produced a phenomenon in which, under some operating conditions, LED lighting fixtures exhibit condensation. Said condensation collects on the inside of the emitting face of the fixture housing and adversely impacts the production of useful light by, e.g., diffusing light. Thus, there is room for improvement in the art.

Areas of improvement include one or more of (a) more effective moisture removal by ability to place desiccant proximate areas of concern inside fixtures without interference with light output of the fixtures, (b) ability to efficiently install in original equipment manufacturing (OEM) and/or in situ after installation, as well as repair and maintain functionalities; and (c) economy in terms of cost of materials originally and over useful or normal operating life of lighting fixtures as well as manufacturing, assembly, and operation.

III. SUMMARY OF THE INVENTION

Under some operating conditions of LED lighting fixtures, a phenomenon has been observed wherein condensation forms on the inner side of the emitting face of the fixture housing. Condensation has been particularly observed in LED lighting fixtures operated outdoors in cold environments, particularly in specialty LED lighting fixtures that have a large number of light directing and/or light redirecting devices, and/or are operated at high current (which correlates to a higher internal housing temperature)—though it is possible condensation could occur under other operating conditions. It is believed that in the transition to higher operating temperatures, operating conditions, and materials, more moisture is released, evaporated, or otherwise produced during normal fixture operation, and when normal fixture operation occurs in a cold ambient environment, said release of moisture results in condensation; this is because said fixtures are sealed at the factory prior to shipping (e.g., to deter theft, to prevent dirt from coating light directing and/or light redirecting devices) and so moisture is trapped within the internal space of the fixture housing. A rough analogy is instructive. Sufficient raising of the temperature of a metal pot of cold water on a stove, with a glass lid or cover, can eventually results in some change of liquid state to gas state. This evaporation then results in condensation on the interior side of the glass lid or cover. Similarly, in the present context, condensation or other moisture formation on any part of a glass at the emitting face of a lighting fixture would also affect the transmission of light from the sources inside the lighting fixture through the glass due to the condensation.

To date, there is no known commercially available solution to correcting or preventing this phenomenon. For example, commercially implemented membrane vents which have long been used with sealed LED lighting fixtures are effective at maintaining a desired pressure in a sealed LED lighting fixture, but have not been shown to provide a similar benefit to maintaining a desired moisture level. In fact, in outdoor or non-hermetic/environmentally controlled environments, the presence of a membrane vent can actually cause moisture ingress over time. Also, it is not viable to simply leave lighting fixtures unsealed because, as discussed, dirt can accumulate on light directing and/or light redirecting devices and adversely impact the production of useful light by, e.g., diffusing light or reducing transmission efficiency.

It is therefore a principle object, feature, advantage, or aspect of the present invention to improve over the state of the art and/or address problems, issues, or deficiencies in the art.

Envisioned are apparatus, methods, and systems for retrofitting or otherwise modifying sealed LED lighting fixtures already in operation (i.e., in situ) to reduce moisture which can cause condensation under at least some operating conditions. An LED lighting fixture field-modified in this manner is then sealed and operated until its natural end of life. As envisioned, by reducing moisture, moisture is not removed from the fixture entirely; rather, it is absorbed by desiccant material exposed to an internal space of the fixture so it is not available to cause condensation and impact the usefulness of light produced from the lighting fixture. This is important to note because future operation of the LED lighting fixture will result in the ingress of moisture (e.g., via a membrane vent), and so by leaving the desiccant in the lighting fixture (or otherwise exposed to the internal space of the lighting fixture) there is an opportunity to provide ongoing reduction of moisture which can cause condensation. This can include a sufficient type, quantity, and moisture-gathering capacity of desiccant material to effectively function without maintenance or change-out for a predicted or normal operating life of the fixture, which could be years if not decades.

Further envisioned as an aspect of the invention are methods, apparatus, and systems for producing in OEM or in situ retrofitting moisture-reducing assemblies inside lighting fixtures which utilize a carrier of embedded desiccant to allow flexibility and ease of fitting at specific locations within the fixture—without material effect of fixture light output or operation.

Further objects, features, advantages, or aspects of the present invention may include one or more of the following:

a. adaptation and application of the aforementioned apparatus, methods, and systems for a fixture fabrication, assembly, or testing factory setting (e.g., to avoid the phenomenon entirely);
b. adaptation and application of the aforementioned apparatus, methods, and systems across a range of desiccant material forms, compositions, and capacity to absorb moisture;
c. adaptation and application of the aforementioned apparatus, methods, and systems across a range of means for affixing desiccant material in situ or in original equipment manufacturing (OEM) relative to the internal space of a lighting fixture; and
d. apparatus, methods, and systems for determining an adequate amount of said desiccant material regardless of the source of said moisture for given intended operating conditions and useful or normal operating life.

These and other objects, features, advantages, or aspects of the present invention will become more apparent with reference to the accompanying specification and claims.

IV. BRIEF DESCRIPTION OF THE DRAWINGS

From time-to-time in this description reference will be taken to the drawings which are identified by figure number and are summarized below.

FIGS. **1-7** illustrate various views of a typical outdoor and/or specialty LED lighting fixture which might experience condensation under at least some operating conditions; note that FIGS. **1-7** do not illustrate the lighting fixture in any particular operational orientation/aiming. FIG. **1** illustrates a perspective view, FIG. **2** illustrates a front view, FIG. **3** illustrates a back view, FIG. **4** illustrates a right side view, FIG. **5** illustrates a left side view, FIG. **6** illustrates a top view, and FIG. **7** illustrates a bottom view. Note that in FIG. **7** the emitting face glass is hatched to indicate it is light transmissive but features normally viewable through the glass are not illustrated (though this is merely for convenience).

FIGS. **8** and **9** illustrate various views of the fixture of FIGS. **1-7** as modified according to aspects of the present invention; here a first embodiment including an interior bagged desiccant in whatever form (e.g., a plurality of relatively small particles, larger collective masses, etc.) with associated structure in the lower hemisphere of the lighting fixture. FIG. **8** illustrates a front perspective view more or less in a correct operational orientation (e.g., 30 degrees down from horizontal) and FIG. **9** illustrates a reduced-in-scale partially exploded front perspective view; note that for clarity no LEDs, LED boards, light directing and/or light redirecting devices, or electrical connections are illustrated.

FIGS. **10** and **11** illustrate various views of the fixture of FIGS. **1-7** as modified according to aspects of the present invention; here a second embodiment including an interior moldable desiccant (e.g., a manually malleable or plastic volume or mass) in the lower hemisphere of the lighting fixture. FIG. **10** illustrates a front perspective view more or less in a correct operational orientation (e.g., 30 degrees down from horizontal) and FIG. **11** illustrates a reduced-in-scale partially exploded front perspective view; note that for clarity no LEDs, LED boards, light directing and/or light redirecting devices, or electrical connections are illustrated.

FIGS. **12** and **13** illustrate various views of the fixture of FIGS. **1-7** as modified according to aspects of the present invention; here a third embodiment including an interior loose desiccant (e.g., plurality of relatively small particles) in the upper hemisphere of the fixture. FIG. **12** illustrates a perspective view more or less in a correct operational orientation (e.g., 30 degrees down from horizontal) and FIG. **13** illustrates a reduced-in-scale partially exploded perspective view; note that for clarity no LEDs, LED boards, light directing and/or light redirecting devices, electrical connections, or desiccant are illustrated, and further note that for clarity some fastening devices and explosion lines have been omitted.

FIGS. **14** and **15** illustrate various views of the fixture of FIGS. **1-7** as modified according to aspects of the present invention; here a fourth embodiment including an interior loose or bagged desiccant in the upper hemisphere of the fixture. FIG. **14** illustrates a perspective view more or less in a correct operational orientation (e.g., 30 degrees down from horizontal) and FIG. **15** illustrates a reduced-in-scale partially exploded perspective view; note that for clarity no LEDs, LED boards, light directing and/or light redirecting devices, electrical connections, or desiccant are illustrated, and further note that for clarity some fastening devices and explosion lines have been omitted.

FIG. **16** illustrates one possible method of calculating a needed amount of desiccant to reduce moisture given anticipated ambient conditions, operating conditions, and/or lifespan of a lighting fixture having a defined internal space.

FIGS. **17** and **18**A-C are FIGS. **6**A and FIGS. **13**A-C, respectively, of incorporated U.S. Patent Publication No. 2014/0092593 and illustrate non-limiting examples of such things as, inter alia, LED light sources, mounts, and orientations inside a fixture, a glass cover that can seal the internal space of the fixture, light directing and light redirecting devices, which are capable individually or in any combination to be used in any of the exemplary embodiments described herein.

FIGS. **19-25** illustrate various views of an alternative design of an outdoor and/or specialty LED lighting fixture which might experience condensation under at least some operating conditions; note that FIGS. **19-25** do not illustrate the lighting fixture in any particular operational orientation/aiming. FIG. **19** illustrates a front perspective view, FIG. **20** illustrates a front view, FIG. **21** illustrates a back view, FIG. **22** illustrates a right side view, FIG. **23** illustrates a left side view, FIG. **24** illustrates a top view, and FIG. **25** illustrates a bottom view. Note that in FIGS. **19** and **20** the emitting face glass is hatched to indicate it is light transmissive but features normally viewable through the glass are not illustrated (though this is merely for convenience).

FIGS. **26** and **27** illustrate various views of the fixture of FIGS. **19-25** as modified according to aspects of the present invention; here an embodiment according to aspects of the claimed invention including a flexible carrier body with embedded desiccant with associated structure adapted to affix the desiccant in situ proximate one or more edges of an inner surface of the emitting face glass of the lighting fixture. FIG. **26** illustrates a partially exploded back perspective view, and FIG. **27** illustrates an enlarged, isolated, back perspective view of this embodiment as installed on a housing of the lighting fixture of FIGS. **19-25**; note that for clarity no LEDs, LED boards, light directing and/or light redirecting devices, or electrical connections are illustrated.

FIGS. **28-34** illustrate various views of another alternative design of an outdoor and/or specialty LED lighting fixture which might experience condensation under at least some operating conditions; note that FIGS. **28-34** do not illustrate the lighting fixture in any particular operational orientation/aiming. FIG. **28** illustrates a perspective view, FIG. **29** illustrates a front view, FIG. **30** illustrates a back view, FIG. **31** illustrates a right side view, FIG. **32** illustrates a left side view, FIG. **33** illustrates a top view, and FIG. **34** illustrates a bottom view. Note that in FIGS. **28** and **29** the emitting face glass is hatched to indicate it is light transmissive but features normally viewable through the glass are not illustrated (though this is merely for convenience).

FIGS. **35** and **36** illustrate various views of the fixture of FIGS. **28-34** as modified according to aspects of the present invention; here an embodiment including a flexible carrier body with embedded desiccant with associated structure adapted to affix the desiccant in situ proximate one or more edges of an array of LED light sources of the lighting fixture. FIG. **35** illustrates a partially exploded perspective view; note that for clarity no LEDs, LED boards, light directing and/or light redirecting devices, or electrical connections are illustrated. FIG. **36** illustrates an enlarged, isolated, rotated 180 degrees, perspective view of this embodiment as installed on the thermally conductive substrate which acts as the mounting surface for the LEDs of the lighting fixture of FIGS. **28-34**.

FIG. **37** illustrates one possible option or alternative for both shape of desiccant and quantity of fastening devices; here, showing said flexible carrier body with embedded desiccant bent or otherwise formed in shape, and omitting fastening devices in parts **212/219** for clarity.

FIG. **38** illustrates one possible option for a knuckle for use with at least some embodiments (also referred to as an adjustable armature) for mounting any of the aforementioned lighting fixtures to a pole, crossarm, or other elevating structure; here, reproducing FIG. 2 of incorporated U.S. Patent Publication No. 2014/0092593.

FIGS. **39** and **40** illustrate two possible alternative designs of LED lighting fixtures which may be used with one or more of the embodiments of the present invention; here fixtures **10000** and **11000** including knuckles and external visors to better ensure light emitted from the LEDs contained therein produces useful light.

V. DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

A. Overview

To further an understanding of the present invention, specific exemplary embodiments according to the present invention will be described in detail. Frequent mention will be made in this description to the drawings. Reference numbers will be used to indicate certain parts in the drawings. Unless otherwise stated, the same reference numbers will be used to indicate the same parts throughout the drawings. Also, similar parts between embodiments—for example, the glass at the emitting face of the lighting fixtures, which is a common feature between all embodiments—will have similar reference numbers; for this example, following an "X03" notation where "X" is a number (e.g., 103, 203, and 803). Lastly, FIGS. **17**, **18**A-C, and **38** are reproduced from U.S. Patent Publication No. 2014/0092593 incorporated by reference herein; those figures have been reproduced faithfully and so, unless otherwise explicitly stated herein, any reference numbers contained in FIGS. **17**, **18**A-C, and **38** should be taken with respect to the specification of U.S. Patent Publication No. 2014/0092593. Specifically, reference nos. **10**, **10**A, **10**B, **10**C, **10**D, **10**E, **10**F, **10**H, **300**B, **301**, **302**, and **303** of FIG. **17**, reference nos. **10**, **200**, **300**A, and **300**C of FIGS. **18**A-C, and reference nos. **100**, **200**, **300**, **400**, and **1000** of FIG. **38** refer to various fixture components or locations that are further discussed in U.S. Patent Publication No. 2014/0092593.

Regarding terminology, the terms "lens" and "glass" are used herein to describe different parts, though they are sometimes used interchangeably in the art. Generally speaking, as described herein, an LED light source includes an integral primary lens, might include a secondary lens (e.g., for beam shaping), and a fixture itself includes a glass or similar member to close (and optionally, seal) against an opening into a housing where a plurality of LEDs with their associated primary and secondary lenses are housed (i.e., over at least a portion of an emitting face). As a specific example, FIG. **36** illustrates an array of LED light sources **9000** each of which includes one or more LEDs (with integral primary lens) and a secondary lens; in practice array **9000** is mounted on the surface indicated at "A" on FIG. **35** prior to sealing part **802** with glass **803** against part **800** (e.g., with sealant and fastening devices). Compare the "lenses" of array **9000** to FIGS. **7-15**, **19-20**, **26-29**, and **35-37** each of which illustrates a "glass" **103/203/803** which seals against an opening into a housing where LED light sources are contained. Said glass **103** or **203** or **803** is typically at least substantially light-transmissive. It might not substantially alter that light transmission or cause any substantial beam shaping from the light generated by the light source(s) and light directing and/or redirecting devices sealed in the fixture, but, under some conditions, might do either (e.g., if coated with an anti-reflective coating or might have a lens-like characteristic that directs or redirects light). Thus, use of the terms lens and glass should be taken in the context in which they are used. Other terms are used by way of convenience and are generally interchangeable: "water" or "moisture"; and "device", "feature", "structure", "part", "member", or "portion", for example.

With further regards to terminology, aspects of the present invention are directed to reducing gas or liquid phase moisture in LED lighting fixtures, at least in the sense it is disabled from availability to condense on the inside of fixture surfaces to a degree that it materially affects light fixture output or operation of components internal to the lighting fixture. It is important to note that, in one context, moisture is described as being absorbed by one or more desiccant materials; the terms "absorb" and "absorption" are used generically to indicate the taking in and holding of a gas or liquid (or vapor) regardless of normal operating conditions (e.g., if the interior temperature promotes evaporation), and no discussion is given herein regarding specific forms of absorption (e.g., solvent, osmotic, capillary, adsorption)—all of which are understood by those skilled in the art to be possible and envisioned under use of the general terms "absorb" and "absorption". Further, reduction of moisture can include moisture in liquid form (e.g., condensation) or in gas form (sometimes referred to as vapor in the industry)—and while water is specifically referenced, aspects of the present invention are not limited to such (e.g., other substances, mixtures, or mixtures with water with at least some analogous properties to water, including phase change between liquid and gas with temperature). Lastly, reduction of moisture does not necessarily mean complete removal of moisture. For example, at least some embodiments are designed such that desiccant is removable (e.g., when a desiccant material is fully saturated)—in this sense moisture is gathered by the desiccant over some time (though some is still technically existing in the internal space; e.g., in or on parts of the fixture or in the volume of air remaining inside the fixture), and then that moisture gathered and trapped by the desiccant is fully removed from the internal space. In other embodiments the desiccant is never removed and so technically the moisture always exists in the internal space but it is reduced in the sense that the volume gathered and trapped by the desiccant is not available for causing the adverse effects already described, even during conditions that risk causing undesirable moisture, including higher temperatures during light source operation at higher power levels. It should be appreciated that regardless of whether moisture gathered and trapped by the desiccant is fully removed from the lighting fixture or merely gathered and trapped at some point by the desiccant within the fixture but the desiccant is not removed, the goal is to reduce condensation which can negatively impact a lighting design by, e.g., reducing the portion of light that is useful—and that this can be achieved with permanent or removable means and methods, and regardless of where or how the moisture is absorbed. All of the aforementioned are possible, and envisioned, according to aspects of the present invention.

B. LED Lighting Fixture, Generally

The exemplary embodiments envision apparatus, methods, and systems of reducing moisture which gathers, forms, condenses, or otherwise exists on an interior surface of an LED lighting fixture under certain operating conditions. Generally speaking, LED lighting fixtures which exhibit condensation are operated outdoors and/or at elevated temperatures (e.g., due to a large number of LEDs and/or high operating current). Said lighting fixtures are typically elevated and angled downwardly towards a target area (e.g., at 30 degrees below horizontal with varying degrees of panning left and right). In this operational orientation, condensation or excess moisture is most likely to collect on the lower hemisphere of a fixture glass at the emitting face of the fixture because of gravity and the nature of a generally round fixture/emitting face. Of course, this could differ based on different operational orientations or with different styles/shapes of glass; compare, for example the shapes of glasses **103**, **203**, and **803**. U.S. Patent Publication No. 2014/0092593—FIGS. **6**A and FIG. **13**A-C of which are reproduced as FIGS. **17** and **18**A-C herein—is incorporated by reference herein in its entirety and illustrates some possible operational orientations, styles/shapes of glass, and examples of LEDs, LED boards, light directing devices (e.g., secondary lenses), and light redirecting devices (e.g., visors) which may form an LED light source.

FIGS. **1-7** illustrate a generic LED lighting fixture **1000** as just described, which might exhibit condensation under some operating conditions. Fixture **1000** generally includes a thermally conductive substrate **100** which acts as the mounting surface for LEDs on one side (i.e., the side internal to the fixture), and which also acts as the mounting surface for one or more heat sink/radiating fins **101** on one side (i.e., the side generally opposite to the LED surface side and external to the fixture). An internal space in the fixture is defined by one side of substrate **100**, inner surfaces of walls of a housing **102**, and an inner surface of an emitting face glass **103** (also referred to as a glass cover) insomuch that it covers an open face of the lighting fixture. It is this internal space of the housing, and sealed with glass **103**, which heats and cools, contains the LEDs and at least some associated light directing and/or light redirecting devices (see LED light source (also referred to as modules) **10** of FIGS. **17-18**C), and is generally desired to be sealed (e.g., to prevent dirt accumulation), yet maintain an acceptable pressure via commercially available membrane vents **104** (e.g., any of the outdoor protective vents available from W.L. Gore & Associates, Inc., Newark, Del., USA).

Of course, in some cases, glass **103** forms a part of a larger assembly including at least a sealing device and lens ring designed so to be removable (see, e.g., U.S. Pat. No. 7,527,393 incorporated by reference herein). As an alternative approach, glass **203** or **803** forms a part of a larger assembly in which it is held in situ by mechanical devices internal to the lighting fixture (see device assembly **220**, later discussed) in combination with fastening devices **301** external to the lighting fixture—which can be designed so to create a temporary or permanent seal (e.g., if combined with adhesive near glass edges). However, regardless of whether emitting face glass **103**/**203**/**803** is designed to be removable or the permanent seal must be broken to modify lighting fixtures already in the field, a method for reducing moisture in said LED lighting fixtures is as follows.

C. Exemplary Method

To reduce moisture over a predetermined period (e.g., over a normal operating life of a lighting fixture), the exemplary embodiments rely upon desiccant materials; different methods of installation, location of material (e.g., relative an internal space, emitting face, or LED light source of the lighting fixture), form (e.g., rigid particles alone or bagged, desiccant embedded in a flexible carrier body), and/or composition of desiccant (e.g., gel, molecular sieve), type of desiccant (e.g., clay, silica, calcium chloride), and/or the like are explored. Regardless, it can be important to first determine, predict, or estimate how much moisture is present (e.g., in the case of field repairs) or will likely be present over the life of a fixture (e.g., if designing for it in a factory setting); one possible method of doing such is illustrated in FIG. **16**.

According to a first step **7001** of method **7000**, the initial water content in the fixture is determined. Step **7001** requires some basic knowledge of relative humidity and temperature when the lighting fixture was first assembled/sealed to understand how much water is present in a defined internal space—this knowledge should be readily known by the manufacturer of the fixture, but could also be estimated. For example, assuming an internal fixture space volume of approximately 1400 cubic inches, and fixture sealing at approximately 25° C. and 60% relative humidity, yields an anticipated water weight of approximately 0.4 grams in the volume of air of the internal space. However, as discussed earlier, this is not the entirety of moisture which may be present in the internal space. For example, some moisture whether in liquid, solid, or gas phase may not be gathered and trapped by the desiccant. But it is important to understand that any gathering and trapping by the desiccant can have beneficial effects. Some of the remaining moisture may not, as a practical matter, be gathered and trapped by desiccant. But, again, one can estimate or predict even roughly the amount of moisture using the above or similar techniques, and can select type, amount, characteristics and placement of desiccant within a given fixture based on that estimate to promote the benefits of gathering and trapping at least some of what otherwise might result in the moisture producing undesirable optical effects.

A second step **7002** comprises determining, predicting, or estimating the water content in any light directing and/or light redirecting devices themselves (e.g., secondary lenses, holders for secondary lenses); see, for example, FIG. **17** for an example of a single holder comprising pieces **10**B and **10**H, single light directing device (secondary lens **10**E), and single light redirecting device (visor **10**F), and FIG. **36** which illustrates an array **9000** of holders and secondary lenses. It has been found that silicone secondary lenses are more hygroscopic than acrylic, for example, and therefore, retain more moisture. Therefore, baking/burnout (or other applications of heat) procedures well known to those skilled in the art to disassociate moisture from conventional secondary lenses may not be suitable to fully remove moisture from silicone secondary lenses, for example. Thus, it may not be practically possible to remove all such retained moisture inside the fixture. But, according to aspects of the invention, the exemplary embodiments are beneficial to address at least some interior moisture for the benefits discussed herein. Also, some of the retained moisture in hygroscopic materials, like the moisture gathered and trapped by desiccant, may stay absorbed even during high temperature operating conditions of the fixture, and thus not affect the optical properties of the fixture. Further, moisture can be introduced into the system over time (which is later discussed)—in particular, in outdoor or non-hermetic/environmentally controlled environments—and so understanding absorption with respect to the light directing devices and light redirecting devices is a critical step. As such, in accordance with step **7002**, light directing and/or light redirecting devices in the internal space may be fully saturated, weighed, moisture removed according to standard baking/burnout procedures, weighed, and the difference in weight assumed to be a minimum water weight retained by the devices. For the specific scenario of approximately 1400 cubic inches of internal fixture space utilizing two-hundred twenty-eight silicone secondary lenses with associated holders, a water weight of approximately 6.5 grams associated with the secondary lenses/holders is reasonable. Similar or analogous techniques can be used for this purpose, and for other parts or materials that have or might have retained water or moisture.

To this point there are two water weights in consideration—that in the air in the fixture, and that associated with the light directing and/or light redirecting devices. According to step **7003** (which is relevant primarily for outdoor and/or non-hermetic environments), water content associated with ambient and operating conditions may be assessed. Typically, LED lighting fixtures used in said outdoor and specialty lighting applications are cycled on and off many times, in every season, for many years. As such, according to step **7003**, it is beneficial to look at the ambient conditions in which the lighting fixture will operate—for example, average ambient temperatures and humidity levels, as well as anticipated fixture temperature during operation and number of operating hours—to get an idea of water content. As previously stated, sealed LED lighting fixtures are often equipped with a commercially available membrane vent (e.g. **104** or **204**) to maintain adequate pressure, so there is a repeated and regular exchange of air within the fixture (and the moisture it carries) and air outside the fixture (and the moisture it carries). In practice, calculations according to step **7003** will vary greatly depending on operating hours and geographic area, for example, but assuming a lifespan of 10 years and around 50 power-on cycles per year (i.e., where fixtures are fully lit and heat up, and then are turned off and fully cool down), 315 power-off cycles per year (because moisture is being introduced into the system even when LEDs are not in operation, albeit at a different rate), in an average outdoor environment (e.g., a non-powered fixture temperature never more than 40° C. above or below ambient), it is not unreasonable to assume the lighting fixture having the aforementioned internal space would take on approximately 45 grams of water over its lifespan.

Having in hand the anticipated water content from steps **7001**, **7002**, and **7003**, according to step **7004** a total water capacity needed from a desiccant material may be determined. Different desiccants have different weights, different capacities for absorbing moisture, and different material properties (e.g., some may be corrosive or otherwise unsuitable for use near LED boards)—all of the aforementioned factor in determining a quantity and type of desiccant according to step **7004**. Such information is typically available from desiccant manufacturers, but could be obtained by empirical testing. It is not unreasonable to assume a lighting fixture of the aforementioned characteristics may require a desiccant quantity on the order of 250 grams (assuming 20% water absorption by weight for the desiccant) to absorb an adequate amount of moisture to avoid condensation over the life of the fixture (here, 10 years for a new fixture). If a field repair situation, method **7000** as just described could be modified as needed to address a portion of operating life (e.g., lifespan calculations or estimations based on 1 year of remaining life, for example). And, of course, as new desiccant materials are developed with greater capacity for water absorption (e.g., 40%), a smaller quantity (e.g., 100 grams) may only be needed.

As will be appreciated, the forgoing calculations can be estimates based on the indicated factors. It is not necessarily required they be made with any high precision or accuracy. Such calculations/estimates can be rough and be effective for the purposes herein. One can use techniques, such as are deemed practical, to optimize such calculations/estimates. One can also take the calculation/estimate and, as might be practical, over-design the capacity of the desiccant to have higher confidence that it will be reasonably effective for all foreseeable conditions for a selected amount of time and operation, whether the full expected effective life of the fixture or some fraction thereof.

D. Exemplary Apparatus Embodiment 1

FIGS. **8** and **9** illustrate a first embodiment; note that for clarity no LEDs, LED boards, light directing and/or light redirecting devices, or electrical connections are illustrated (see FIGS. **17**-**18**C for examples of at least some of the aforementioned). Here, a desiccant material **303** of assembly **300** is inserted into housing **102** of fixture **3000**, and held in place via fastening devices **301** extending through a hold-down plate **302** and into complementary portions **304** of housing **102**. Here, desiccant material **303** is encased or contained in at least a gas permeable bag (it could be at least partially liquid permeable) so long as the material retains the desiccant. Such bag material can be the same or similar to that used in any of the wide variety of bagged desiccants that are put in packaging of products to absorb moisture. The material of the bag should allow sufficient transfer of moisture to the desiccant to be effective for the purposes described herein.

Primary benefits of the present embodiment are such that (i) since assembly **300** is physically near the site of condensation in the lower hemisphere of the internal space of the fixture, moisture is rapidly collected and removed from interior emitting face of glass **103**, and (ii) the present approach can be readily implemented in a factory setting and therefore an amount/type/capacity of desiccant can be selected such that field repairs are never needed during an anticipated fixture lifespan. That being said, the present embodiment (i) does require breaking a seal at glass **103**/housing **102** (which is often intended to be a permanent seal) in a field repair situation, (ii) can be difficult to install in a field repair situation if feature **304** (or similar structure) is not available, and (iii) depending on the optical characteristics of part **302**, could impact transmission of light from inside the fixture to outside the fixture to the target area so to reduce useful light.

E. Exemplary Apparatus Embodiment 2

FIGS. **10** and **11** illustrate a second embodiment; note that for clarity no LEDs, LED boards, light directing and/or light redirecting devices, or electrical connections are illustrated (see FIGS. **17**-**18**C for examples of at least some of the aforementioned). Here, a desiccant material **400** is piped into, foamed, or otherwise formed in place in some portion of the lower hemisphere of the internal space of fixture **4000**. In practice, any of a variety of moldable desiccants could be used; for example, those available from DryTech, Inc., Cookstown, N.J., USA.

Primary benefits of the present embodiment are such that (i) since desiccant **400** is physically near the site of condensation in the lower hemisphere of the internal space of the fixture, moisture is rapidly collected and removed from interior emitting face of glass **103**, and (ii) the present approach can be readily implemented in a factory setting and therefore an amount/type/capacity of desiccant can be selected such that field repairs are never needed during an anticipated fixture lifespan. That being said, the present embodiment (i) might require breaking a seal at glass **103**/housing **102** in a field repair situation (unless, for example, it can be piped into an existing aperture (e.g., from a removed or modified membrane vent)), and (ii) moldable desiccant may be more expensive or more difficult to apply in situ than in other exemplary embodiments.

F. Exemplary Apparatus Embodiment 3

FIGS. **12** and **13** illustrate a third embodiment; note that for clarity no LEDs, LED boards, light directing and/or light redirecting devices, electrical connections, or desiccant are illustrated (see FIGS. **17**-**18**C for examples of at least some of the aforementioned). Here, a loose desiccant material (not shown) of assembly **500** is poured into a perforated aluminum alloy tube **501** within the internal space of fixture **5000**. As can be seen, perforated tube **501** exists in sections, each section closed at opposite ends by a cap **503** once desiccant is inserted, the desiccant having a particle size larger than the perforations so to avoid spilling out (e.g., 2-4 mm diameter silica gel beads available from Dry & Dry, Brea, Calif., USA). One possible means of affixing tubes **501** in situ is to rely upon existing portions **304** of housing **102** by affixing a first portion of a bracket **502** to said portion **304** (e.g., via fastening device **301**), and securing (e.g., via rivets **504**) a tube section **501** to a second portion of said bracket **502** (note two styles of bracket **502** are illustrated in FIG. **13**).

Primary benefits of the present embodiment are such that (i) because assembly **500** is located in the upper hemisphere of the lighting fixture it is not likely useful light will be impacted, and (ii) the present approach can be readily implemented in a factory setting and therefore an amount/type/capacity of desiccant can be selected such that field repairs are never needed during an anticipated fixture lifespan. That being said, the present embodiment is difficult to machine and therefore difficult to mass produce; however, it might be useful in a field repair situation if the tubes could be fed into an existing aperture (e.g., from a removed or modified membrane vent) and secured in situ (whether in the manner just described or otherwise).

G. Exemplary Apparatus Embodiment 4

FIGS. **14** and **15** illustrate a fourth embodiment; note that for clarity no LEDs, LED boards, light directing and/or light redirecting devices, electrical connections, or desiccant are illustrated (see FIGS. **17**-**18**C for examples of at least some of the aforementioned). Here, a loose desiccant material of assembly **600** is poured into an aperture of a first perforated anodized sheet metal cartridge portion **602** which is affixed (e.g., via rivets **504**) to a second perforated anodized sheet metal cartridge portion **601**. After a sufficient amount of desiccant is inserted into the space defined by parts **602**/**601**—the desiccant having a particle size larger than the perforations so to avoid spilling out (e.g., said silica gel beads) and/or including a filter **604** (e.g., polyester or other fabric able to function at high temperatures)—said aperture is closed with a cap **603**. Assembly **600** is affixed to some feature (e.g., existing portion **304** by fasteners **301**) in the upper hemisphere of the internal space of fixture **6000**.

Primary benefits of the present embodiment are such that (i) because assembly **600** is located in the upper hemisphere of the lighting fixture it is not likely useful light will be impacted, and (ii) the present approach can be readily implemented in a factory setting and therefore an amount/type/capacity of desiccant can be selected such that field repairs are never needed during an anticipated fixture lifespan. That being said, the present embodiment requires more material and machining than other embodiments set forth.

H. Exemplary Apparatus Embodiment

FIGS. **19**-**25** illustrate an alternative design of an outdoor and/or specialty LED lighting fixture which might experience condensation under at least some operating conditions; here a square, rectangular, or otherwise shaped lighting fixture which has angular features where moisture may condense (as opposed to round-like features with defined curvature/hemispheres as in Embodiments 1-4). However, like previous embodiments, fixture **2000** includes a thermally conductive substrate **200** which acts as the mounting surface for LEDs on one side (i.e., the side internal to the fixture), and which also acts as the mounting surface for one or more heat sink/radiating fins **201** on one side (i.e., the side generally opposite to the LED surface side and external to the fixture). Further, fixture **2000** includes an internal space defined by one side of substrate **200**, inner surfaces of walls of a housing **202**, and an inner surface of an emitting face glass **203**; note that for clarity no LEDs, LED boards, light directing and/or light redirecting devices, or electrical connections are illustrated (see FIGS. **17-18**C, and **36** for examples of at least some of the aforementioned). Fixture **2000** may additionally include a surface **205** for mating to a knuckle (later discussed). A vent **204** to the internal space is positioned on housing **202** or elsewhere. Fasteners **301** removably attach housing **202** to substrate **200**.

FIGS. **26** and **27** illustrate various views of the fixture of FIGS. **19-25** as modified according to this embodiment. Here, desiccant is embedded in a flexible carrier body, and the combination of desiccant and carrier body can be cut to size, flexed into a desired shape, and secured in situ. As such, such flexible desiccant can be flexed around one or more sides of glass **203** (e.g., so to approximate the perimeter of glass **203**); if operation shows condensation occurs at some sides of glass **203** but not others, carrier body/desiccant **211** can be installed at just those sides (e.g., to save cost).

In one non-limiting example, it has been found that structural foam spacers traditionally used in window insulation (e.g., model SUPER SPACER® TriSeal™ Premium available from Edgetech (UK) Ltd, Coventry, England) work well to promote the benefits of gathering and trapping at least some of what otherwise might result in the moisture producing undesirable optical effects in a lighting fixture. The SUPER SPACER® material is an extruded, thermoset polymer structural silicone foam spacer with integrally incorporated desiccants. It is thermoset and can not be reshaped through reheating, retains its flexibility over a wide temperature range, and has excellent resistant to ozone, sunlight, and oxidation. It does not blister or bubble. It comprises a carrier which is a flexible gas and liquid permeable material defining a volume, and the desiccant is distributed throughout the volume. It is marketed for perimeter insulation for sealed insulting glass units for sealing, energy efficiency, spacing of glazing from its framework, and compensating of glazing stresses. Further details can be found at en.quanex.com/broschuren/ and select "IG Manufacturers Bochure (DIN A4)(PDF), accessed May 25, 2021 at https://en.quanex.com/broschuren/. It can be purchased in a variety of sizes. Examples include a few millimeters in height (e.g. 3-8 mm), by a few millimeters in width (5-20 mm) by rolls that can be many feet in length (and then cut to length for applications). As such, for these types of insulating strips for glazing of these types of sizes, it can be reverse engineered how much internal volume for a given strip height and width cut to a certain length, so its moisture-absorbing capacity and desiccant efficiency can be roughly estimated. Empirical testing or information from manufacturers can also reveal the same; see again discussion regarding method **7000**. For details about one way to embed a desiccant into a foam carrier, see patent no. U.S. Pat. No. 9,803,415 incorporated by reference herein.

In this example of Super Spacer" insulator strip material, the foam is a rectangular in cross-section spacer tube and has a desiccant (3 A molecular-sieve; 47% minimum by weight) embedded in the foam. It is shipped in sealed bags to retain desiccant protection prior to installation and use. One example of a desiccant is silica gel. Others are possible (activated charcoal, calcium sulfate, calcium chloride, and molecular sieves (e.g. zeolite spheroids). However, as will be appreciated, other flexible material with desiccant properties and types can be used, whether or not with other features such as vapor barriers and the like that, for example, are included in window insulation strips or materials.

As can be seen from FIGS. **26** and **27**, in this embodiment a positioning assembly **210** is used to mount the flexible carrier containing desiccant in its operational orientation. Assembly **210** includes a device **220**, carrier body/desiccant **211**, and one or more rigid members **212/219** formed from sufficiently thin material (e.g., 0.030" thick sheet aluminum) which can be drilled, scored and bent, or otherwise adapted to secure carrier body/desiccant **211** in an operational orientation. Here device **220** includes a central aperture portion **221** through which a fastening device **301** extends and threads into or otherwise comes into operative connection with a receiver **215** which, together with portions **217** and **218** of device **220**, clamps (or otherwise mounts) and positions emitting face glass **203** in situ on body **202**. If desired, portion **216** of device **220** could be internally threaded so that a fastening device **301** could extend through aperture **213** of parts **212/219** and into part **216** so to effectively clamp down on carrier body/desiccant **211** (note that desiccant **211** is not pierced or threaded as it is sized to stop short of aperture **213** when fastening device **301** is present)—but this may not be necessary in some applications as oftentimes clip portions **214** of device **220** are sufficient to resiliently restrain parts **212/219** against a surface of portion **216** and effectively mount and position parts **212/219** in situ. As such, FIG. **26** illustrates that the flexible and elongated nature of desiccant **211** allows it to be used with positioning assembly(ies) **210** of a variety of configurations, both linear and with bends, curves, compound shapes, etc.; and positioning assembly(ies) **210** can cooperate with mounting members or hardware to position desiccant **211** at or near a desired internal position. Here, that position is proximate the interior side of face glass **203** but, in particular and beneficially, at or outside the perimeter of glass **203** so as not block any substantial portion of glass **203** in a way that materially affects operation of lighting fixture **2000**, including blocking light designed to be emitted for illumination purposes. As will be appreciated, FIG. **26** shows a combination that places desiccant **211** in that position relative to glass **203** along a bottom edge and one side edge. Of course, similar positionings could be added along all or a portion of the top edge and the other side; or just along any one of the top, bottom, side, or opposite side edges (or any portion thereof), or any combination of the foregoing.

In this embodiment, the framing of face glass **203** includes body **202**. Body **202** has a depth which extends the plane of face glass **203** away from the plane of substrate **200**. This provides depth for placement of positioning structure(s) **210** and desiccant **211** around but near face glass **203** (see, in particular, FIG. **27**).

Note further that in this embodiment the perimeter of face glass **203**, as well as the perimeter of body **202**, are smaller in area than substrate **200** (compare that to face glass **103** perimeter area and expanding perimeter area of body **102** relative to smaller perimeter area of substrate **100** of embodiments 1-4). As such, this stepping down of perimeter areas from substrate **200**, to body **202**, to then face glass **203** presents challenges to positioning desiccant close to but without substantial interference with face glass **203**. In FIG. **26**, the framing around the perimeter of face glass **203** further allows positioning assembly(ies) **210** to mount near face glass **203** without blocking or obstructing the face glass.

Benefits of the present embodiment are such that (i) because assembly **210** is located behind portions of housing **202** and not directly viewable through emitting face glass **203**, it is not likely useful light will be impacted, (ii) the present approach can be readily implemented in a factory setting and therefore an amount/type/capacity of desiccant can be selected such that field repairs are never needed during an anticipated fixture lifespan, and (iii) the present embodiment is a lower cost option than at least some other embodiments. That being said, the present embodiment uses a smaller overall amount of desiccant as compared to at least some other embodiments (here because both the internal space of fixture **2000** and available mounting locations is limited compared to, for example, fixture **1000**) so it is possible in at least some extreme operating conditions field replacements of carrier body/desiccant **211** may be needed.

I. Exemplary Apparatus Embodiment

FIGS. **28-34** illustrate another alternative design of an outdoor and/or specialty LED lighting fixture which might experience condensation under at least some operating conditions; here again a square, rectangular, or otherwise shaped lighting fixture which has angular features where moisture may condense (as opposed to round-like features with defined curvature/hemispheres as in Embodiments 1-4)—but with different features on surfaces external to the internal space of the fixture and which aid in producing useful light (here, ribbing on housing **802**). FIGS. **38-40** (later discussed) illustrate additional external features (e.g., knuckles, external visors) which contribute to providing useful light.

Like the previous embodiment, in addition to said housing **802** fixture **8000** includes a thermally conductive substrate **800** which acts as the mounting surface for LEDs on one side (i.e., the side internal to the fixture), and which also acts as the mounting surface for one or more heat sink/radiating fins **801** on one side (i.e., the side generally opposite to the LED surface side and external to the fixture), as well as a mating surface **805** to affix the lighting fixture to a knuckle. Further, fixture **8000** includes an internal space defined by one side of substrate **800**, inner surfaces of walls of housing **802**, and an inner surface of an emitting face glass **803**. Note that for clarity no LEDs, LED boards, light directing and/or light redirecting devices, or electrical connections are illustrated (see FIGS. **17-18**C, and **36** for examples of at least some of the aforementioned).

FIGS. **35** and **36** illustrate various views of the fixture of FIGS. **28-34** as modified according to a still further embodiment. As in the previous embodiment, desiccant is embedded in a flexible carrier body; however, unlike that embodiment, here desiccant **211** is clamped (or otherwise mounted and/or positioned in situ) via structure affixed to thermally conductive substrate **800** and proximate the LED light source, rather than the lighting fixture housing and proximate the emitting face (as in the previous embodiment). As can be seen from FIGS. **35** and **36**, desiccant **211** is positionally affixed in rigid members **223/225** (which are similar in composition and function to parts **212/219**) and, optionally, in combination with spacers **222/226** are positioned proximate array of LED lights sources **9000** when parts **223/225** are secured (here, via fastening devices **301** through apertures **224/213**, respectively, and into complementary threaded holes **806**). Here, spacer **222** serves another purpose—it acts as a wire management system (e.g., for containing and restraining wiring for the LEDs)—and spacer **226** serves another purpose—it acts to hold a filter—but this is specific to the design and operation of fixture **8000**, and so parts **222/226** may not be present in all applications of this embodiment.

Benefits of the present embodiment are such that (i) since desiccant **211** is physically near the parts most likely to release moisture (i.e., LED array **9000**), moisture is rapidly collected and removed before it can condense on emitting face glass **803**, (ii) the present approach can be readily implemented in a factory setting and therefore an amount/type/capacity of desiccant can be selected such that field repairs are never needed during an anticipated fixture lifespan, and (iii) the present embodiment is a lower cost option than at least some other embodiments. That being said, the present embodiment uses a smaller overall amount of desiccant as compared to at least some other embodiments (here because both the internal space of fixture **2000** and available mounting locations is limited compared to, for example, fixture **1000**) so it is possible in at least some extreme operating conditions field replacements of carrier body/desiccant **211** may be needed.

J. Options and Alternatives

The invention may take many forms and embodiments. The foregoing examples are but a few of those. To give some sense of some options and alternatives, a few examples are given below.

As has been stated, condensation on the interior side of a glass at the emitting face of an LED lighting fixture can be undesirable because it impacts the transmission of light from inside the fixture to outside the fixture to the target area; namely, it reduces the usefulness of light. This could be a concern with fixtures of a different design than those illustrated herein, with light sources other than LEDs, with different or additional light directing and/or light redirecting devices, with different operational orientations, with different styles of fixture glass, and under operating conditions other than those discussed herein. For example, lighting fixtures and/or glass could be rounded and/or having pronounced curvature (as in Embodiments 1-4, and FIGS. **18**A-C and **38**), or may be rectangular, square, wedge-shaped, or having some angular surface and/or edges (as in Embodiments 5 and 6, and FIGS. **37**, **39**, and **40**). The lighting fixture design itself may differ in terms of parts at a general level—for example, fixture **8000** does not include a membrane vent—or at a very specific level—for example, the light directing devices of array **9000** of LED light sources differ in design from light directing device **10**E of LED light source **10** of FIG. **17** (LED light source **10** further including a light redirecting device **10**F). All are possible options and alternatives envisioned according to aspects of the present invention.

Further, while specific desiccant forms, shapes, and materials have been discussed herein, others are possible—for example, in some embodiments, desiccant can be solid, loose, bagged, etc. and in others desiccant is embedded in a flexible carrier- and in such an event, certain devices may likewise take on a different shape or form (e.g., perforations in parts **501**, **602**, and **601** may be larger, smaller, rounder, more square, etc.). FIG. **37**, for example, illustrates the aforementioned flexible carrier body with embedded desiccant **211** bent or otherwise formed to match a general curvature of emitting face glass **203**.

With further regards to options and alternatives, discussion has been given herein to light directing devices, light redirecting devices, and the glass which seals against the emitting face of a lighting fixture; while some optical properties have been discussed (e.g., anti-reflective properties, beam shaping, light transmission), it is important to note that a wide variety of optical properties exist, and any lighting fixtures or devices having such may likewise benefit from aspects according to the present invention. For example, "glass" as it has been used herein describes a device which seals or closes against the open or emitting face of a lighting fixture; said glass could be fully transmissive, or translucent, or coated with a filter or a color gel, for example. As another example, at least some light directing and/or light redirecting devices may exist outside the internal space of the lighting fixtures. FIG. **38** illustrates a knuckle assembly **100** (again, using the numbering from incorporated U.S. Patent Publication No. 2014/0092593) which can be pivoted in both vertical (i.e., about its connection point to a crossarm or other elevating structure) and horizontal (i.e., about its mid-point bolt) planes to provide light redirection of an entire LED lighting fixture when said fixture is affixed to said knuckle (i.e., at mating surface **205/805**). FIGS. **39** and **40** illustrate LED lighting fixtures **10000** and **11000**, respectively, with different designs of knuckle and also including visors (i.e., light redirecting devices) outside the internal space of the LED lighting fixtures. All are possible options and alternatives envisioned according to aspects of the present invention.

Lastly, reference has been given herein to fastening devices, and devices which are mounted or affixed to a surface; it is important to note that a variety of means exist to join, abut, or affix devices in a removable or permanent fashion (e.g., taping, gluing, welding, etc.), and that all are possible, and envisioned. For example, many embodiments are described as having to break a seal to be installed in a field repair situation. In many instances, rather than remove the glass of a fixture, existing apertures (e.g., from a removed or modified membrane vent) could be retrofitted in a permanent fashion (e.g., by installing brackets inside the aperture against an inner surface/wall of the fixture) to hold temporary desiccant packets or structure filled with desiccant in an operational orientation such that, when desired, a "used" packet or carrier of desiccant can be removed from such a "port" and replaced with a new one, and then, if required sealed (e.g., via a cap) or otherwise positioned. In this sense both permanent and temporary means are used to provide an adequate solution; this and all of the aforementioned is possible, and envisioned. Also, it is to be understood that fastening devices in general may differ in quantity, form, or type depending on the needs of an application. For example, FIG. **37** illustrates fixture **2000** with no fastening devices in parts **212** and **219**, even though there are apertures **213** in said parts. For some applications the structure of device assembly **220** is sufficient to resiliently retain parts **212/219**, and by extension, desiccant **211** without at least some quantity of fastening devices. Again, all of the aforementioned are possible, and envisioned.

What is claimed is:

1. A device to reduce moisture in a lighting fixture comprising:
- a. a desiccant material embedded in a carrier body; and
- b. one or more parts to affix the carrier body with embedded desiccant material relative to a portion of the lighting fixture in an internal space of the lighting fixture, wherein the one or more parts comprise:
  - i. a first structure affixed to the portion of the lighting fixture; and
  - ii. a second structure adapted to resiliently restrain the carrier body with embedded desiccant material.

2. The device of claim **1** wherein the carrier body is flexible and the one or more parts further comprise structure to resiliently restrain the carrier body with embedded desiccant material when flexed into a shape.

3. The device of claim **2** wherein the portion of the lighting fixture comprises a housing having a perimeter, and wherein the shape of the flexed carrier body with embedded desiccant material approximates a perimeter of a glass at the housing.

4. The device of claim **3** wherein the perimeter of the glass at the housing is smaller than the perimeter of the housing, and wherein the glass at the housing defines an emitting face of the lighting fixture.

5. The device of claim **1** in combination with a lighting fixture wherein the lighting fixture contains a plurality of LEDs on one or more LED boards.

6. The combination of claim **5** wherein the desiccant material is non-corrosive with respect to LEDs or LED boards.

7. The combination of claim **5** further comprising one or more light directing or redirecting devices associated with the plurality of LEDs.

8. The combination of claim **7** wherein the desiccant material is selected, at least in part, on an amount of moisture contained in or absorbed by the one or more light directing or redirecting devices.

9. The device of claim **1** wherein the desiccant material is selected, at least in part, on capacity to absorb an amount of moisture over an operating lifespan of the lighting fixture.

10. The combination of claim **7** wherein the light directing device comprises a secondary lens.

11. A method of reducing moisture in an internal space of a lighting fixture comprising:
- a. determining an amount of moisture to be reduced in the lighting fixture over a predetermined time period;
- b. determining a size and shape of flexible carrier body with embedded desiccant having a capacity to absorb the amount of moisture over the predetermined time period; and
- c. installing the flexible carrier body with embedded desiccant in a structure affixed to a portion of the lighting fixture in the internal space of the lighting fixture such that the flexible carrier body with embedded desiccant is positioned in situ relative to a feature of the lighting fixture.

12. The method of claim **11** wherein the step of installing the flexible carrier body with embedded desiccant in a structure affixed to a portion of the lighting fixture comprises installing the flexible carrier body proximate one or more sides of a light transmissive surface of the lighting fixture in the internal space of the lighting fixture.

13. The method of claim **12** wherein the light transmissive surface of the lighting fixture defines an emitting face of the lighting fixture and wherein the structure affixed to a portion of the lighting fixture is installed such that it (i) is not directly viewable through the light transmissive surface and (ii) does not adversely impact useful light produced by the lighting fixture.

14. The method of claim **11**, wherein the step of installing the flexible carrier body with embedded desiccant in a structure affixed to a portion of the lighting fixture comprises installing the flexible carrier body proximate one or more sides of an LED light source in the internal space of the lighting fixture.

15. A lighting fixture comprising:
- a. one or more light sources mounted to a substrate in thermal contact with a heat sink;
- b. a body with an internal space extending from the substrate to an opening;
- c. a glass face mounted at the opening to the body and having an interior side exposed to the internal space of the body; and

d. a carrier embedded with a desiccant positioned in the internal space at one or more of a perimeter of the glass face or the light sources effectively outside light output from the light sources and one or more parts to affix the carrier body with embedded desiccant material relative to a portion of the lighting fixture in the internal space of the lighting fixture;

e. so that the desiccant position is effective to deter or remove condensation of moisture on the interior side of the glass face.

16. The lighting fixture of claim **15** wherein the carrier is a flexible gas and liquid permeable material defining a volume, and the desiccant is distributed throughout the volume.

17. The lighting fixture of claim **16** wherein the carrier is a flexible foam and the desiccant is any of a molecular sieve, silica gel, or silica beads.

18. The lighting fixture of claim **15** wherein the size, shape, and volume of the carrier and the type, amount, and distribution of the embedded desiccant is predetermined based on an estimation of desiccant efficiency needed to effectively deter condensation inside the fixture over a predetermined time period.

19. The lighting fixture of claim **18** wherein the predetermined time period is an estimated useful or normal operating life of the lighting fixture.

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